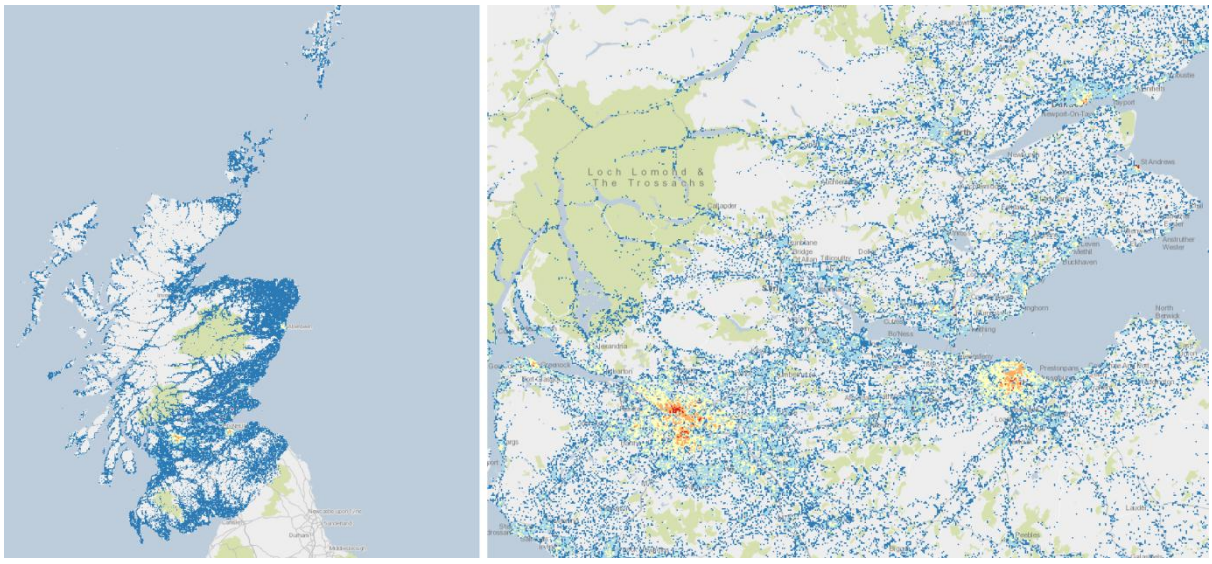
Scotland Heat Map
User guide

2.1 Manual



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Initial Methodology Report prepared by Carbon Trust Resources and Ramboll Energy for the Scottish Government.

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2.0 Methodology report

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Contents

1. Introduction

1.1 Scotland heat map – user guide

This document is **Scotland heat map – user guide 2.1 manual**. It is part of a suite of user guide for the Scotland heat map. These can be downloaded from www.scotland.gov.uk/heatmap.

2.0 Methodology report
2.1 Manual
2.2 Metadata, limitations and data management
2.3 Local knowledge validation & improvement process
2.4 Scotland heat map – interactive and local web

This manual covers two areas:

Creating the national dataset
This focuses on the role of Scottish Government, but is useful to understand the data within the heat map and for managing local data to be used in the national heat map. **This information is highlighted in purple**.

Using the local datasets
This focusses on the role of local authorities. It describes how to import the heat map and the methodology and calculations used to create it. It also describes each of the datasets and defines some suggested uses of the map. **This information is highlighted in orange**.

1.2 Why develop a heat map?

Heat mapping is a powerful way to visualise and assess who needs heat, where sources of heat might come from and how these can be connected in an efficient way to reduce the cost of heat supply and the carbon intensity of heat generation. It can also be used, in combination with other spatial datasets as a tool to illustrate the socio-economic benefits of changing existing paradigms of heat supply.

Each Scottish local authority has been offered the heat map dataset for their area to support local energy planning. This requires acceptance of the Framework Agreement[1].

Councils starting work on their own heat map have set up working groups to manage set up and use. Typically the group has an overall lead (often from Planning or Sustainability but this is down to local choice). Other group members often included representatives from GIS, energy management, housing, economic development. A number of roles in managing and delivering the heat map outlined in **Scotland heat map – Framework** 2.4 organisation contact form. If an organisation plans to provide data for the Scotland heat map then they will also want to identify data owners for each data source **Scotland heat map user guide –** 2.2 metadata, limitations and data management.

[1] www.scotland.gov.uk/heatmap

The heat map dataset is very flexible and uses a GIS interface which allows analysis with other spatial datasets. The Scottish Government has issued advice[2] on the role of planning authorities in the transition to efficient, low carbon and renewable heat. This advice describes how the heat map can support planning authorities in developing policy, strategic development planning and at determination stage.

The heat map can be used for detailed analysis at national and local level. It allows calculation and spatial representation of heat supply and demand and as an initial stage in site identification and feasibility. There are layers of amalgamated data for public and reporting purposes. The heat demand data, and to an extent the neat supply data, are linked to property UPRN which means it can be connected to a huge variety of spatial datasets held by Scottish public sector bodies.

A wide range of data has been drawn together to provide the highest quality map possible. The Scotland heat map containing aggregated data held by Scottish Government is publicly available at www.scotland.gov.uk/heatmap, showing potential heat demand of areas.

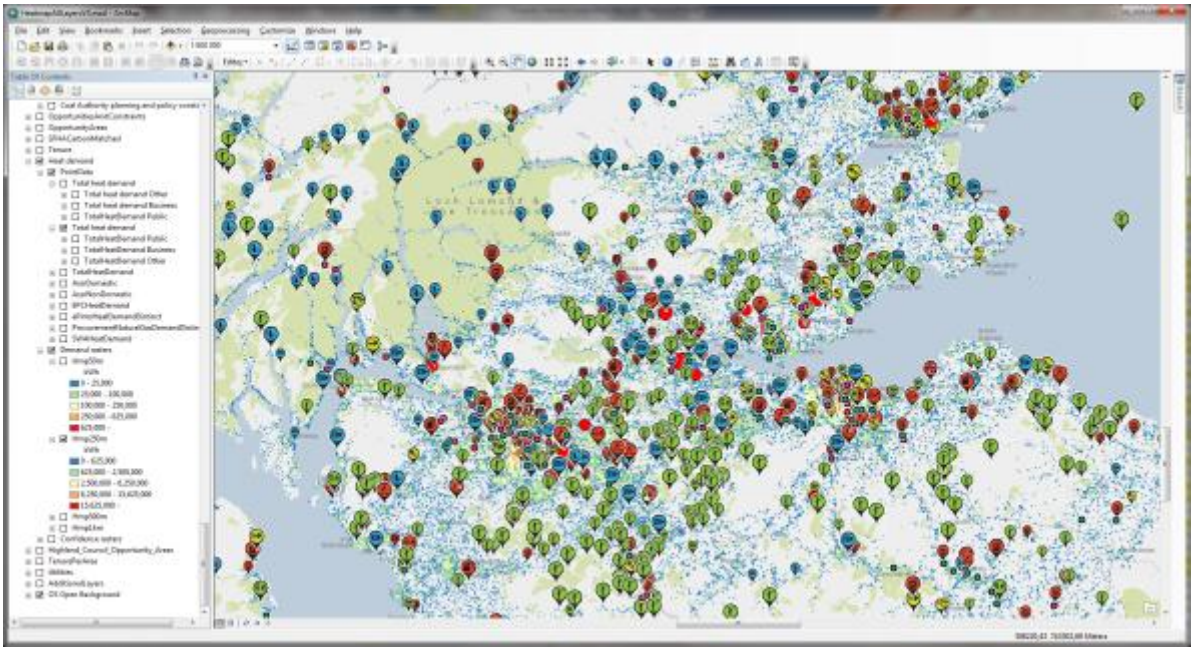


Figure 1: Illustration of data available in the heat supply and demand layers of the map

[2] Scottish Government Planning and Heat online renewable planning advice (Scottish Government)
http://www.scotland.gov.uk/Resource/0042/00422374.pdf

1.3 Structure of the Manual

Section 2 of the manual provides a guide on how to import and work with the Scotland Heat Map. This includes full metadata for each layer package and details of the most appropriate software to use for data handling at various stages of the process.

Sections 3, 4 and 5 provide comprehensive instructions on how to generate the heat map. However these can also be useful for using the local datasets and creating data that can be fed back into the national map.

Text shown in square brackets indicates a database title, for example:

[HEAT_DEMAND] or [HEAT_SUPPLY].

Text shown in alternative font indicates field titles, for example:

`POSTCODE` or `HEAT_DEMAND`.

This alternative font is also used to show examples of SQL queries.

2. Importing the Scotland heat map

2.1 Importing the heat map to a local system

The heat map is developed in ESRI file-based geodatabases. Local authorities should outline advice if other formats are required. If ESRI's desktop software is being used, installation of the heat map is very simple:

1. Copy the folder to a designated folder on the local network. On this folder user rights can be administrated as required.
2. Open the ArcMap file "HeatmapAllLayersxx.mxd". Now all the layers should be visible in the table of content to the left as illustrated in the figure below:

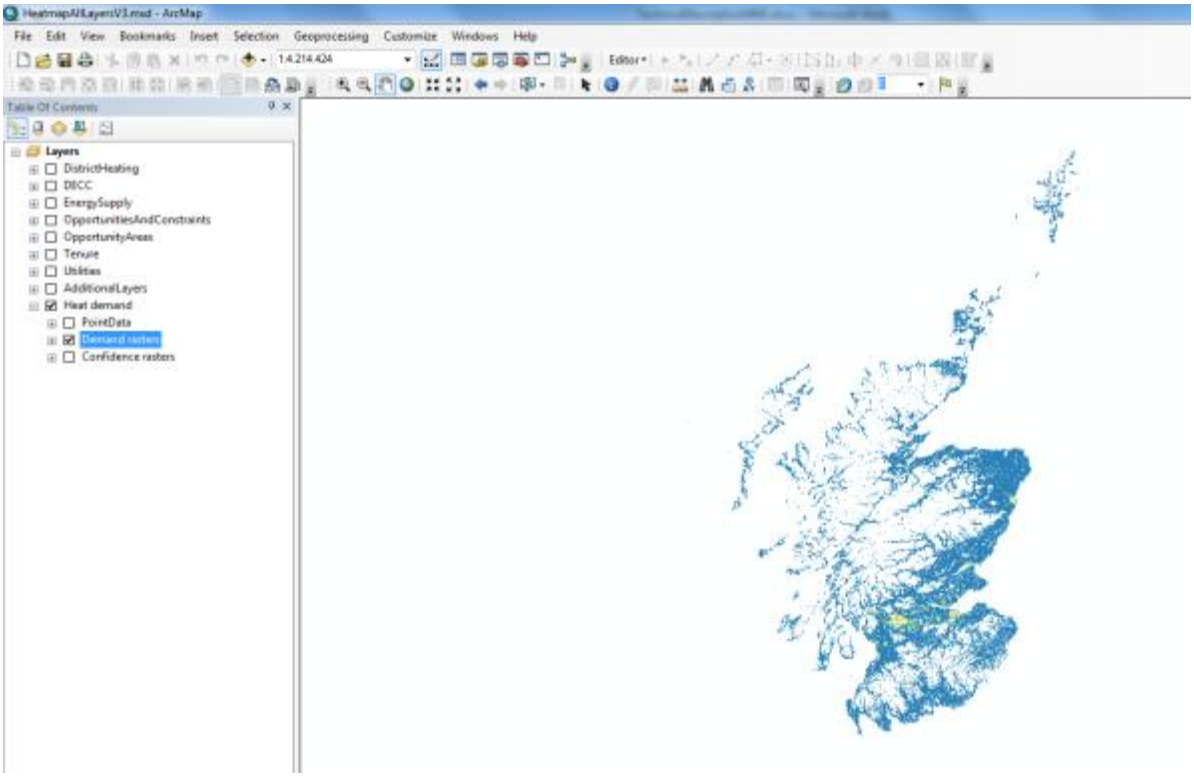


Figure 2: Image of the imported ArcMap file

If the layers are not visible, but the headers in the table of content are marked with a red exclamation mark (see Figure 3) then the layer cannot locate the data source and a link must be created manually. If the geodatabase folder was copied to a separate local folder as described, this should not be necessary. If it is desirable to take a copy of the .mxd document to another location on a desktop or network, note that it is likely that the links will have to be re-established.

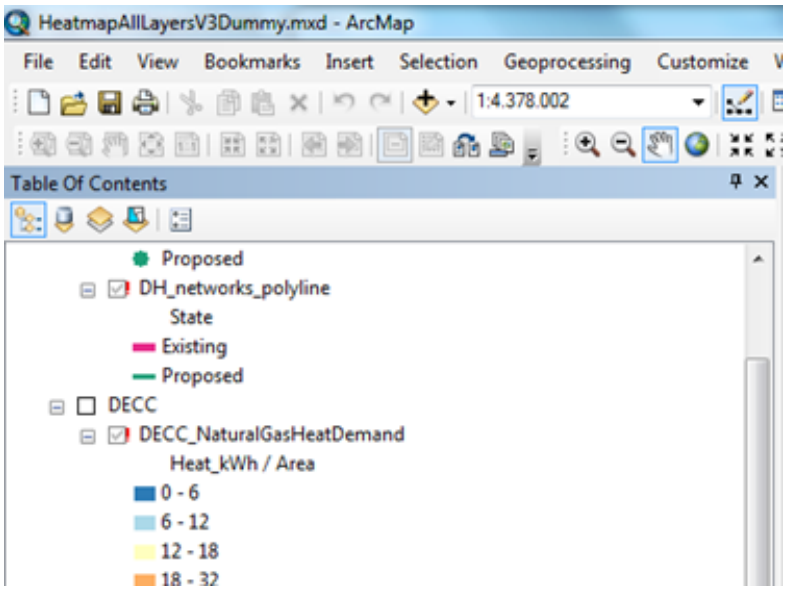


Figure 3: Example of layers which must be manually linked to the geodatabase

If heat map must be installed in formats other than ESRI, Scottish Government can provide a set of data for most common GIS formats. If installation to a GIS server system is preferred, all the data must be uploaded and the symbology may have to be re-created for each layer.

2.2 Heat Map Contents

The Scotland Heat Map is divided into nine layer groups. Each group contains data from several sources. A small number of above sub-layers have been made available only to the Scottish Government and therefore they are unavailable to other organisations. However the contact details of relevant organisation can be provided should local authorities which to set up separate data sharing agreements with these organisations.

Table 1 shows the data sets contained within each layer group.

Table 1: Description of layers in the Scotland Heat Map

Layer Group	Sub -layers
Heat Demand	Heat demand by property (point data)
	Heat demand rasters (50m, 250m, 500m & 1 km resolution.
	Major heat anchor loads
	Confidence level raster
Tenure	Tenure by area (Census by data zone)
	SFHA point data
	Housing association point data (where separate from SFHA)
	Local authority point data
Heat Supply	Suppliers point data (all technology)
	Wind farms (polygons)
	Geothermal layers

	Coal Authority
	Forestry Commission
	Borehole Temperatures
District Heating Networks	Heat Network Partnership point data
	EST point data
	SG network layouts (polylines)
	DH network operator layouts (polylines)
Planning and Economic Development	Local Development plan areas
	Building rates for LDP area
	Planning permissions
	Building completion certificates
Opportunities and Constraints	Historic Scotland data on buildings and areas of heritage value
	Conservation areas
	Scottish Index of Multiple Deprivation
Layer Options	Scotland boundary outline
	Local Authority (council) boundary outlines and names
	Intermediate Geography outlines
	Data Zone (boundary outlines and identifiers)
	Postcode area outlines
Additional	Settlement boundaries
Utilities Layouts	Gas pipes (provided by SGN)

A small number of above sub-layers have been made available only to the Scottish Government and therefore are unavailable to other organisations. However, the contact details of relevant organisation can be provided should local authorities which to set up separate data sharing agreements with these organisations.

The Heat Demand layer group is considered to be the most important of all the heat map layer groups and is structured as shown in Table 2.

Table 2: Heat Demand data layer field information

Type	Name	Description
GeoDB	**HeatDemandLyr.gdb**	Geodatabase containing just this one layer
Feature Class	HeatDemand*xxx* (Can be called HeatDemandIntermed/HeatdemandLyr1 or similar)	The principal heat demand layer, unifying the information from the sub-layers. Rasters are based on the heat demand from this layer. The basis of this layer is the points from OS AddressBasePlus, hence most of the fields are described in the accompanying metadata-description for this product.
Fields	UPRN	The UPRN values, used as the fundamental join field to other datasets.
	Xcoord	X-coordinates (British National Grid)
	Ycoord	Y-coordinates (British National Grid)
	CalcCode	Code for the source of the heat demand value, i.e. the sub-layer and possibly selected parts of this, based on

		availability of data. *See table 1
	HeatDemand	The heat demand value in KWH, obtained from the source of highest quality
	BM	Benchmark values, used for some of the CalcCode values
	MM_Area	The area of the polygon that the point falls within in the OS Master Map product. Used as base-value in benchmarking (CalcCode=1)
	HD_KM2	Correction to KWH/Year/KM2 as described in manual (HeatDemand x 0.04566)
	Confidence	The confidence assigned to the heat demand value.
	MM_TOID	The ID of the OS Master Map polygon
	SourceType	The type of source (Domestic, non-domestic or other).
GeoDB	**HeatDemandSubLayers.gdb**	Geodatabase containing the sub-layers
Feature class	ActualHeatDemand	Heat demand based on actual billing data from local authorities etc.
	AssrDomHeatDemand	Heat demand based on assessors domestic data
	AssrNonDomestic	Heat demand based on assessors non-domestic data
	EPCHeatDemand	Heat demand based on EPC data
	ePIMsDemand	Heat demand based on ePIMs data
	SWAHeatDemand	Heat demand based on data from the Scottish Whisky Association

2.3 Software

Consideration must be given into the choice of software for:

- Data management
- Processing of databases
- Mapping

Factors which affect the choice of software include:

- the size of the data set (MS Excel and MS Access may not hold records on a national scale)
- whether complex calculations need to be carried out (complex queries on large data sets require a lot of processing)
- what the final output should look like.

The creation of maps for the Scotland Heat Map has been carried out using ESRI ArcGIS. Although many local authorities use ESRI ArcGIS, other packages include Smallworld, Quantum and StatMap. Data will be provided in the most common formats.

The heat map has been produced using various software tools. Due to the very large amount of data received in the project, standard desktop software such as MS Excel and Access has not been adequate for processing and MS SQL-server has been used as the final collecting point for most of the calculated datasets.

ArcGIS desktop software with the extension “Spatial analyst” has been used for all GIS handling and map production.

MS Excel and MS Access have been utilised for most of the initial data management, cleaning and merging of datasets besides calculation of benchmarks on selected datasets.

MS SQL-server (SQL Express and SQL Server Professional) and Microsoft SQL Server Management Studio have been used for later data management, handling of large, merged datasets, address matching and final calculations of heat demands.

2.4 Methodology Overview

The overall handling of data follows this workflow:

1. Data validation and cleaning in standard software an MS Excel, text editors and MS Access.
2. Merging of datasets to a common table setup – this in Access or on SQL server.
3. Final data cleaning and alignment of datasets.
4. Adding and updating common fields in SQL Management Studio.
5. Create feature classes in ArcGIS, based on xy-coordinates or the UPRN number from the tables.

As described in **user guide document** 2.0 Methodology Report, the methodology for developing a heat map is a circular process. Once the final map is produced improvements and developments are made by returning to the beginning of the process.

3. Data gathering, review and modification

This section outlines the initial data gathering, validation and cleaning stages of creating the heat map.

3.1 Data Management

Due to the high number of records provided by a multitude of sources, a strict data management procedure is essential throughout construction and maintenance of the Scotland Heat Map. As each set of information is received it should be tracked through the data processing, database structuring and mapping process.

Data should be stored according to layer group and source and a thorough record must be kept of when data is received or updated.

During the creation of the Scotland Heat Map, a data checklist spreadsheet was used to record the incoming data. The fields contained within the data checklist are listed in the table below:

Table 3: Data checklist fields for data management

Field	Description
Stakeholder	The name of the data provider
Contact Details	Contact details for the data provider
Status	The level of communication with the stakeholder
Information	What data is expected to be received
Responsible Person	The organisation responsible for requesting the data
RFI Sent	Has the request been sent – Y/N?
Confirmation of Receipt	Has the stakeholder acknowledged the request?
Request Date	When was the data requested?
Data Received	Has the data been received – Y/N?
Received Date	When was the data received?
Data in Server	Has the data been saved to the appropriate place?
Initials	Within the organisation creating the map, who will be responsible for processing the data?
Data Cleaned	Has the data been cleaned?
Database Complete	Has a complete database been created?
Link	Hyperlink to data location (if saved on a network)

All organisations providing data to the heat map have been assigned a unique reference number. These are listed in **Scotland heat map user guide –** 2.0 methodology report along with an indication of the data that was provided by each organisation. This reference number will be contained within a field entitled `ORG_NO`, which will enable the user to trace the origin of the data. Additionally the user will be able to filter the data by source and gain a clear picture of types of heat demand.

In addition to the data sources listed in **Scotland heat map user guide –** 2.2 metadata, limitations and data management, various supplementary data sources are used in calculations to create the final heat demand figures. These include data

sets such as national benchmark figures and degree days and these are also included in the user guide – 2.2.

The data provided for the heat map has varying conditions for use. Some is open data, some can be viewed publically but only shared at an aggregated level, and some is not available publically, but can be used for broader analysis such as statistical analysis and research. Guidance is provided in the Framework agreement and associated documents at www.scotland.gov.uk/heatmap.

The heat map dataset is created from the most detailed sources of data available. However the complexity of developing a national dataset mean that there will be duplication and improvements needed. Local knowledge will be key to improving the quality of the dataset over time. There will be an initial validation and improvement period to the 31 August 2014 and then an ongoing validation and improvement process outlined in **Scotland heat map user guide –** 2.3 Local knowledge, validation and improvement.

Ongoing data management will be required. Local updates to data will need to be fed back to into the national map update process to ensure they are incorporated. This will require standardised data management processes and schema, including standard drop down menus. The approach is outlined in **Scotland heat map user guide –** 2.2 metadata, limitations and data management.

A systematic approach to the initial data gathering and cleaning stages is essential in delivering and updating a heat map.

Data should be stored according to layer group and source and a thorough record must be kept of when data is received or updated.

3.2 Requests for Data

The foundation layer of the Scotland Heat Map is the OS AddressBase. This provides the addresses and UPRNs of every property in Scotland.

The Unique Property Reference Number (UPRN) is a unique number given to every building in Scotland.

Every council in Scotland holds, manages and maintains a Corporate Address Gazetteer (CAG), which is a spatial dataset that provides the location of every address in the Council area with a range of relevant attribute information. A UPRN is given for every property within the CAG.

As the UPRN provides a direct link to the spatial data set, it is preferable that all data sources state the UPRN for each record. Without the UPRN, address matching must be carried out using alternative fields which can be much less accurate, resulting in some data being excluded from the map.

Public sector bodies are recommended to synchronise their software/databases for energy and asset management to use the UPRN. This would allow easier and more

robust updating of energy data. Where this has been done there have been significant benefits reported within the organisation. Building on the AddressBase is the data from the fourteen Scottish Assessors which provides more detailed information for just fewer than 3 million private properties. The information varies between Assessors, but generally includes fields such as address, building type and floor area.

Data has also been provided by over 100 different organisations which they have either published or provided on request. Scottish Government would like to thank all those organisations.

Future requests to local authorities for energy consumption data will come via ProcExec/ScotExed.

Scottish Government would like to encourage all organisations to use the CAG UPRN as an identifier in their data.

3.3 Generating the Heat Demand Layer

To begin creating the heat demand layer a copy of the AddressBase data set should be created and renamed [HEAT_DEMAND]. The Ordnance Survey AddressBase Plus data has been used as the unifying, unique address/point reference throughout the project. The Address Base data was received as four separate, large text files with a fixed column setup. Headers were downloaded from the Ordnance Survey webpage. Data was imported to SQL server and merged and a point feature class was made in ArcGIS, based on the xy-coordinates in the table. This feature class contained approximately 3.2 million records.

The Master Map was received in the open standard for GIS exchange, GML. These were converted to ArcGIS Feature classes, which is not a direct conversion. Rather, the GML objects have to be assigned as points, lines and polygons and the symbology gets lost in translation. However, the main purpose of the Master map data was to use the local area polygons for assigning an area for first level benchmarking as described in Section 3.6.

The AddressBase and Master Map will form the basis of the heat demand layer package and initially should contain the UPRN and full postal address in addition to any property type information for each record.

Several fields must then be added to this table, which will be explained in the subsequent sections:

- `CONFIDENCE_FACTOR`
- `CALCCODE`
- `MM_AREA`
- `BENCHMARK_HEAT`
- `HEATDEMAND`

In addition to these fields, several other fields will be incorporated into the table as records are superseded by those from more reliable sources, for example the indicators of age and floor areas from the Scottish Assessors.

3.4 Establish Confidence Levels

The heat demand layer is built upwards from general national heat benchmarks applied to all properties, which are then superseded by more reliable values. The reliability of data will be represented by the allocation of a “confidence level” to all records. The confidence levels are shown in Table 5 and range from 1 – 5, where 5 represents the most reliable data.

Table 4: Data sources within each confidence level

Factor	Heat Demand Sources
1	Benchmarking AddressBase footprints
2	Benchmarking of Assessor and ePIMS records where some property information is unavailable
3	Benchmarking of Assessor and ePIMS records where all required information is available
4	EPC and SWA
5	Public sector billing data

3.5 Establish Calculation Codes

Each heat demand record is assigned a calculation code which indicates the calculation method used to produce the heat demand value. The calculation code is dependent on the data source, the amount of information provided and the use of benchmarks.

The following table outlines the calculation codes used for the Scotland Heat Map.

Table 5: Calculation code descriptions and corresponding confidence levels

Code	Properties to Include	Level
0	Properties where no significant heat demand is expected e.g. plots of land or public toilets.	N/A
1	Properties where residential status is assumed from OS footprint, but no other data exists.	1
2	Private non-domestic properties where data exists which categorises property as non-domestic, but no other information is available.	2
3	Private domestic properties where data exists which categorises property as domestic, but no other information is available	2
4	Public non-domestic properties where exists which categorises the property as public non-domestic, but no other data exists.	2
5	Private domestic properties where there is data on age and type, but no floor area.	2
6	Private domestic properties where there is data on age and floor area, but no property type.	2
7	Private domestic properties where there is data on property type and floor area, but no age.	2
8	Private non-domestic properties where there is data on floor area, but property type is unavailable.	2
9	Private non-domestic properties where there is data on property	2

Code	Properties to Include	Level
	type but floor area is unavailable.	
10	Private domestic with only floor area provided	2
11	Private domestic with only building type known	2
12	Private domestic properties where data on age, type and floor area is available	3
13	Private non-domestic properties where data on property type and floor area is available	3
14	Public non-domestic properties where data on property type and floor area is available	3
15	Actual domestic energy data obtained from EPCs	4
16	Properties identified as distilleries	4
17	Scottish Government “procurement” data	5
18	Billing data from public bodies	5

Allocation of calculation codes is most easily done in parallel with the calculations in the form of simple update queries in the `CALCCODE` field. Records which are updated with a calculation are allocated the relevant code.

Alternatively, codes can be allocated to records at a later stage through queries based on the data attributes. This is a more complex process as combinations of attributes may be required to correctly allocate the code. For example the calculation code 5 may only be assigned if floor area is null, but property type and age are not null and can successfully be joined with lookup tables.

3.6 Calculating Building Footprints from AddressBase (`MM_AREA`)

Initially points must be assigned to all areas which correspond with the AddressBase records. These are then filtered to remove areas which have no heat demand, such as roads or monuments. The filter was applied by discarding all records that were not assigned as “building” or “structure”

The `postal_addressable` field can be used to filter the data by selecting and eliminating all “N” values. The remaining records form the foundation of the heat demand feature class.

Where multiple points fall on one polygon, the demand is divided by the number of points which will then make up the appropriate value when summed in the heat demand layer.

3.7 Create Benchmark Lookup Tables

For the lowest three levels of confidence level (1, 2 and 3), benchmark heat demands are applied to each property.

Benchmarks are heat demand figures which are assigned to properties where actual demand data is unavailable. Values are typically presented in kWh/m^2 and therefore floor area is required to calculate the total building demand.

Benchmarks can be calculated from averages of actual demand figures using existing heat demand databases. Also, there are several national benchmark guides where data can be obtained.

As the benchmarks vary by several factors including building type and building age, lookup tables should be created to enable the records to be allocated the correct benchmark using simple join queries. The benchmark heat demand values are contained within the field `BENCHMARK_HEAT`.

3.7.1 AddressBase Benchmarking

The benchmarks at this foundation level feature the lowest confidence level and calculation code as there are two values only: domestic and non-domestic.

The two figures are calculated from the domestic and non-domestic benchmark tables outlined in following sections. All buildings with a footprint less than or equal to 200 m^2 is categorised as domestic and all buildings with a footprint greater than 200 m^2 is categorised as non-domestic. The figures have been appropriately scaled to take outliers into consideration, based on the proportions of floor areas contained in the Scottish Assessors data.

Table 6: Benchmark values allocated to OS footprints

Properties with footprint **≤200 m^2**	**247** kWh/m^2/yr
Properties with footprint **>200 m^2**	**220** kWh/m^2/yr

The calculation required consideration of the overall average benchmarks, the proportion of properties in each category and the total number of properties in each category. These figures are presented in the three tables below and the values are taken into the subsequent equations.

Average benchmark values

	Domestic	Non-Domestic
≤200 m²	178 *x 1.4* = 249 kWh/m²	194 kWh/m²
>200 m²	178 *x 1.4* = 249 kWh/m²	194 kWh/m²

Proportion of properties in each category

	Domestic	Non-Domestic
≤200 m²	95%	34%
>200 m²	5%	66%

Number of properties in each category

	Domestic	Non-Domestic
≤200 m²	2,496,955	74,554
>200 m²	131,419	144,723
Total no. properties	2,628,374	219,277

Hence the benchmarks to be applied are:

Properties in OS with area ≤200 m² $\frac{2{,}496{,}955\times249+74{,}554\times194}{2{,}496{,}955+74{,}554} = 247\ \mathrm{kWh/m^2}$

Properties in OS with area >200 m² $\frac{131{,}419\times249+144{,}723\times194}{131{,}419+144{,}723} = 220\ \mathrm{kWh/m^2}$

3.7.2 Domestic Benchmarks

Domestic benchmarks per m^2 were calculated using the Scottish House Condition Survey (SHCS). Approximately 9,000 records were available comprising 3,000 records from each of the years 2010 to 2012.

Domestic heat benchmarks were divided into the following age groupings:

Table 7: Domestic benchmark age groupings used in the Scotland Heat Map

BENCHMARK_CODE	Building Age
AA	Post 2005
A	1982 – 2005
B	1965 - 1981
C	1945 – 1964
D	1918 – 1944
E	Pre 1918
AB	Assessor data states post 1966
ABC	Assessor data states post 1945
ABCDE	No building age in assessor data

Codes A - E match the age code categories of the SHCS[3]. AA has been added to provide space for future benchmarks to be added. At present the AA and A values are identical.

The three benchmark codes AB and ABC are averages of the combination of individual codes, which can be applied to data which does not state a specific year, but gives a rough indication of time period. ABCDE is an average of all ages for a specified building type and is only applied to those records which contain no information regarding age (see *Calculation Code 7* in Section 4.4).

[3] SHCS age categories were chosen over the Assessors age categories due to there being a higher number which results in greater accuracy.

The domestic heat benchmarks are also divided into four core building types:

- Detached
- Semi-detached
- Terrace
- Flat

Therefore the final domestic heat benchmarking table contains 36 possible heat benchmark figures:

Table 8: Domestic heat benchmark values (kWh/m^2/yr)

	Det.	Semi Det.	Terrace	Flat
AA	238	231	210	188
A	238	231	210	188
B	325	303	250	232
C	385	303	264	242
D	415	319	279	260
E	432	358	320	289
AB	281	267	230	210
ABC	316	279	241	221
ABCDE	359	303	265	242

It should be noted that data sources such as the Scottish Assessors will not often use the simplified categories shown in the header row in Table 8. It is often necessary to create an additional lookup table which assigns one of the four core domestic building types to the specific building types and age codes found in the raw data. In addition the Assessors use two fields which provide an indication of building type: `BUILDING_TYPE` and `DESCRIPTION`.

For example, for the creation of the Scotland Heat Map there were over 1,500 different permutations of domestic `BUILDING_TYPE` and `DESCRIPTION`. These were filtered and divided up into the four core categories and assigned a benchmark.

Description	Building_Type	AA	A	B
APARTMENT	TAO	188	188	232
BEDSIT	FTU	188	188	232
DETACHED		238	238	325
Detached	DET	238	238	325
FarmHouse	DETD	238	238	325
FarmHouse	FLAT	188	188	232
FarmHouse	Not Available	238	238	325
FarmHouse	SDET	231	231	303
FarmHouse	TERR	210	210	250
FLAT		188	188	232
FLAT	1 St. S/D	188	188	232
FLAT	ETR	188	188	232
FLAT	FFG	188	188	232
FLAT	FFU	188	188	232
FLAT	Flat	188	188	232
FLAT	Flat1	188	188	232
FLAT	Flat2	188	188	232
FLAT	Flat3	188	188	232
FLAT	Flat4	188	188	232
FLAT	FTA	188	188	232
FLAT	FTB	188	188	232

Figure 4: Screenshot of extract from domestic benchmark lookup table

Domestic Degree Days

Degree day factors must be applied to these heat demands based on the property location. The 20 year average degree day value from the six relevant weather stations can be used to calculate the Scottish average. The SHCS heat demands were grouped into Local Authority areas and the average was calculated. A degree day factor was then allocated based on the deviation from the degree day average.

The **degree day factor** is a ratio of the average degree days in one region compared to another, where degree days are a measure of heating or cooling.

In the case of the Scotland Heat Map, the degree day factor is the ratio of the Scottish national 20 year average degree day value and the 20 year average of the weather station closest to the property being assessed. This calculation must also take into consideration the proportion of heat demand used for hot water (which is not generally affected by environmental temperature).

An example calculation of the DD Factor for South Ayrshire is shown as follows:

1. Obtain the correct degree day average

   South Ayrshire's relevant weather station is Glasgow. The 20 year average degree day figure for Glasgow is approximately 2317.

2. Obtain the Scottish national degree day average

   The 20 year national average degree day factor is approximately 2558.

3. Calculate the % difference between the two values

   (2317/2558)-1 = -9%

4. Take into account the proportion of heat demand used for hot water (55% estimate)

   1 + 0.55-9% = 0.95* = DD_Factor

The degree days are allocated as shown in Table 9:

Table 9: Domestic degree day factors for each local authority area

ASSR_NO	Local Authority	DD Factor
01	South Ayrshire	0.948
01	North Ayrshire Council	0.948
01	East Ayrshire	0.948
02	Stirling Council	0.948
02	Falkirk Council	0.948
02	Clackmannanshire Council	0.948
03	Dumfries & Galloway Council	1.091

ASSR_NO	Local Authority	DD Factor
04	West Dunbartonshire	0.948
04	Argyll and Bute Council	0.948
04	East Dunbartonshire	0.948
05	Fife Council	0.990
06	Glasgow City Council	0.948
07	Aberdeenshire Council	1.012
07	The Moray Council	1.012
07	Aberdeen City Council	1.012
08	Highland Council	0.989
08	Comhairle nan Eilean Siar	0.989
09	North Lanarkshire Council	0.948
09	South Lanarkshire	0.948
10	West Lothian	0.990
10	Edinburgh City Council	0.990
10	East Lothian Council	0.990
10	Midlothian Council	0.990
11	Shetland Isles Council	0.989
11	Orkney Council	0.989
12	Inverclyde Council	0.948
12	Renfrewshire Council	0.948
12	East Renfrewshire Council	0.948
13	Scottish Borders Council	0.971
14	Angus Council	0.990
14	Dundee Council	0.990
14	Perth & Kinross Council	0.990

Domestic Insulation Factors

Factors must also be applied to account for the level of insulation in buildings as insulation significantly reduces the heat demand. The factors were calculated based on the proportion of buildings within the SHCS to have insulation and the average reduction in demand of those buildings compared to those without insulation.

Table 10: Insulation factors to be applied to each local authority area

Local_Authority	Ins. Factor
Aberdeen City Council	0.709
Aberdeenshire Council	0.611
Angus Council	0.633
Argyll & Bute Council	0.647
Clackmannanshire Council	0.615
Dumfries and Galloway Council	0.592
Dundee City Council	0.709
East Ayrshire Council	0.599
East Dunbartonshire Council	0.616
East Lothian Council	0.641
East Renfrewshire Council	0.632

Local_Authority	Ins. Factor
Edinburgh City Council	0.769
Comhairle nan Eilean Siar	0.577
Falkirk Council	0.640
Fife Council	0.628
Glasgow City Council	0.782
Highland Council	0.603
Inverclyde Council	0.719
Midlothian Council	0.628
Moray Council	0.593
North Ayrshire Council	0.631
North Lanarkshire Council	0.647
Orkney Council	0.591
Perth & Kinross Council	0.633
Renfrewshire Council	0.684
Scottish Borders Council	0.629
Shetland Islands Council	0.602
South Ayrshire Council	0.643
South Lanarkshire Council	0.655
Stirling Council	0.641
West Dunbartonshire Council	0.713
West Lothian Council	0.621

Non-Domestic Benchmarks

Non-domestic heat benchmarks in kWh/m^2/annum were obtained from CIBSE TM46[4].

The benchmarks generally fall into 29 groups:

Table 11: Non-domestic heat benchmarks (kWh/m^2/yr)

Group Description	BENCHMARK_HEAT
No Demand	0
General office	90
High street agency	70
General retail	83
Large non-food shop	128
Small food store	155
Large food store	79
Restaurant	278
Bar, pub or licensed club	263
Hotel	248
Cultural activities	150
Entertainment halls	315
Swimming pool centre	848
Fitness and health centre	330

[4] "Energy Benchmarks TM46: 2008", CIBSE, October 2008 Hyperlink:http://www.cibse.org/knowledge/cibse-tm/tm46-energy-benchmarks

Group Description	BENCHMARK_HEAT
Dry sports leisure facility	248
Covered car park	10
Public buildings with light usage	79
Schools and seasonal public buildings	113
University campus	180
Clinic	150
Hospital (clinical and research	315
Long term residential	315
General accommodation	225
Emergency services	293
Laboratory or operating theatre	120
Public waiting or circulation	90
Terminal	150
Workshop	135
Storage facility	120
Cold storage	60

Similarly to the domestic data, records that require non-domestic benchmarking will not be divided into the above group descriptions. A unique lookup table will have to be created upon receipt of the data to correspond with the description fields in the raw data (see Figure 5).

For the Scotland Heat Map, the Assessor data's building type was indicated through three fields: `BUILDING_TYPE`, `DESCRIPTION` and `SE_CATEGORY`. There were over 2,700 permutations of these fields, which were manually sorted so that the correct group description could be applied.

	A	B	C	F
	SE_Category	Description	Building_Type	HEAT_DEMAND
4	Education and Training	Ability Centre		112.5
5	EDUCATION AND TRAIN	ACTIVITIES CENTRE		247.5
6	EDUCATION AND TRAIN	Activity Area		247.5
7	EDUCATION AND TRAIN	Activity Centre		247.5
8	EDUCATION AND TRAIN	AIR TRAINING SCHOOL(PART)		112.5
9	EDUCATION AND TRAIN	ART GALLERY		150
0	Education and Training	Arts Centre		150
1	EDUCATION AND TRAIN	ASSESSMENT CENTRE		112.5
2	Education and Training	ASSESSMENT CENTRE	office	90
3	EDUCATION AND TRAIN	BOARDING SCHOOL(PART)		112.5
4	Education and Training	CAFE		277.5
5	Education and Training	CAFE	shop	82.5
6	Education and Training	CAFE ETC	shop	82.5
7	EDUCATION AND TRAIN	CHILD & FAMILY CENTRE		112.5
8	EDUCATION AND TRAIN	CHILD DEVELOPMENT CENTRE		112.5
9	EDUCATION AND TRAIN	Child Guidance Centre		112.5
0	EDUCATION AND TRAIN	CLASSROOM		112.5
1	EDUCATION AND TRAIN	Classrooms		112.5
2	EDUCATION AND TRAIN	CLASSROOMS ETC		112.5
3	EDUCATION AND TRAIN	COLLEGE		112.5
4	EDUCATION AND TRAIN	COLLEGE	COLLEGE	112.5
5	EDUCATION AND TRAIN	COLLEGE	INDUST COMPARATIVE	112.5
6	Education and Training	COLLEGE	office	90
7	EDUCATION AND TRAIN	COLLEGE	SCHOOLS	112.5
8	EDUCATION AND TRAIN	COLLEGE ANNEXE		112.5
9	EDUCATION AND TRAIN	COLLEGE(PART)		112.5
0	EDUCATION AND TRAIN	COMMUNITY CAMPUS		112.5
1	EDUCATION AND TRAIN	COOKERY SCHOOL		112.5
2	EDUCATION AND TRAIN	DAY CENTRE		112.5
3	EDUCATION AND TRAIN	EDUCATION CENTRE		112.5

Figure 5: Screenshot of extract from non-domestic benchmark lookup table

As the CIBSE figures are averaged for the UK rather than just Scotland, degree day factors were taken into account based on the property location relative to the UK 20 year average of 2021. The degree days are allocated as follows:

Table 12: Degree day factors for non-domestic buildings

ASSR_NO	Local Authority	DD Factor
01	South Ayrshire	1.081
01	North Ayrshire Council	1.081
01	East Ayrshire	1.081
02	Stirling Council	1.081
02	Falkirk Council	1.081
02	Clackmannanshire Council	1.081
03	Dumfries & Galloway Council	1.261
04	West Dunbartonshire	1.081
04	Argyll and Bute Council	1.081
04	East Dunbartonshire	1.081
05	Fife Council	1.133
06	Glasgow City Council	1.081
07	Aberdeenshire Council	1.161
07	The Moray Council	1.161
07	Aberdeen City Council	1.161
08	Highland Council	1.133
08	Comhairle nan Eilean Siar	1.133
09	North Lanarkshire Council	1.081
09	South Lanarkshire	1.081
10	West Lothian	1.133
10	Edinburgh City Council	1.133
10	East Lothian Council	1.133
10	Midlothian Council	1.133
11	Shetland Isles Council	1.133
11	Orkney Council	1.133
12	Inverclyde Council	1.081
12	Renfrewshire Council	1.081
12	East Renfrewshire Council	1.081
13	Scottish Borders Council	1.109
14	Angus Council	1.133
14	Dundee Council	1.133
14	Perth & Kinross Council	1.133

3.8 Public Sector Energy Demand

Billing data obtained from the public sector is generally provided as fuel used and hence requires the application of conversion factors before it can be used in the final heat map. These should be contained within lookup tables to enable easy update in future (Table 13).

Additionally boiler/burner efficiencies should be applied to the fuel demand to convert it to a heat demand. These assumed efficiencies are also presented in Table 13.

Table 13: Conversion and efficiency factors for public sector billing data

Fuel Type	Conversion to kWh[5]	Units	Efficiency used for Heating and cooling
Gas	1		0.75
Electricity	1		1
Oil	10	kWh/l	0.75
Biomass	3,806	kWh/t	0.75
Fuel Oil	12	kWh/l	0.75
Gas Oil	11	kWh/l	0.75
Kerosene	10.5	kWh/l	0.75
LPG	7	kWh/l	0.75
Coal	7,500	kWh/t	0.75
Heat Networks	1		1
Other	1		0.75

Whilst oil is a generic title for gas oil and kerosene separate rows have been included in the lookup table to cover a wider range of possible responses from stakeholders.

It should be noted that the NHS provided boiler efficiencies, which were averaged across all sites and applied to the data supplied and so in this case no factoring was applied.

For NHS properties the degree days are based on a base temperature of 18.5°C instead of the 15.5°C used for all other data sources.

A further factor to be considered when working through public sector energy demand is that where properties have electric heating the stakeholder will often only provide the total electricity demand and not the proportion of electricity used for heating. In the Scotland Heat Map properties that have their primary heat source from electric heating are assumed to use a proportion of total electricity for heating of 0.7.

The Scottish Government has committed to supporting an update of the heat map in 2015-16. Future updates of the map will require a similar strategy in order to engage with the stakeholders and to gather information from each organisation. The Scottish Government is keen to reduce the effort required from contributing organisations. To provide a secure, efficient and effective electronic data exchange, the Scottish Government has amended a web based data collection and validation tool it hosts called ProcXed. ProcXed has been expanded to allow collection and vali-

[5] "Energy and Carbon Conversions: 2013 Update", Carbon Trust, 2013

dation of any combination of site, building, heating and cooling data. This can be uploaded an upload template, via xml, or input directly to a web form. Further guidance on using ProcXed will be made available to data managers.

3.9 Planning and Economic Development

3.9.1 Future development projections

Each local authority has responsibility for the preparation and maintenance of their Local Development Plan (LDP). Included in this data is Housing Land Allocations (HLA) which identify the projected dwelling numbers within residential development area in the LDP. The HLA identifies the total number of houses allocated as well as a figure identifying the number of properties to be built within the next 5 years. The HLA areas are identified as shape files in the GIS and will be assigned a heat demand density according to the projected number of properties and the following benchmark heat demand. Local Authorities are encouraged to use their own data layers.

3.10 Tenure

Received tenure data is divided into two layer types:

- tenure by area e.g. Census data
- tenure by point e.g. Scottish Federation of Housing Associations data

This enables the heat map user to view the proportions of tenure types over wider areas as well as at individual building level.

The census data was sent with corresponding intermediate data zones which were joined with a list of all intermediate data zones in Scotland which made it possible to map.

Some local authorities and housing associations provided point data with UPRN numbers for most records and addresses could therefore be mapped easily.

3.11 Energy Supply

3.11.1 Role of energy supply data

The draft Heat Generation Policy Statement highlighted the need to make the best use of existing energy, such as unused excess heat and renewables. The energy supply layer highlights these opportunities. Data has been identified from a range of sources that include existing and planned sites for energy generation. A number are available as downloads from websites. The source of energy supply data is found in Appendix A of the **Scotland heat map - user guide** 2.0 Methodology report. This principally identifies heat supply opportunities, however renewable electricity production sites are also included, which could be linked to heat supply and storage, for example through heat pumps.

A particularly under-used opportunity is the unused excess heat from power plants. Often excess heat is emitted into the air through cooling towers or into nearby rivers or oceans. It may also be possible to increase heat yield by diverting low pressure steam from the low pressure turbine stage in steam generation plants which will

result in a small reduction in electricity but a significant increase in overall efficiency by utilising fuel for heating. Overall the combined production of heat and electricity will result in significantly improved efficiency compared to electricity only.

Other sources of unused excess heat are industries which may have unused excess heat or hot water. Distilleries may be a common example of this in certain areas of Scotland. Waste water treatment plants can be options as well because heat from effluent can be boosted in heat pumps and exchanged into district heating; in addition the residual biomass may be used for biogas production.

Besides these possible sources there may be other sources for heating, such as the ongoing research into mine waters; thus, it is highly relevant to map these sources and evaluate the relevance and distance to existing and future network for district heating. For all these heat sources it must, of course, be technically and economically possible to use this heat in order to make it happen.

5,486 records were identified from the following sources. The success rate in matching data and removal of duplicates left 3,191 records in the final map (which included some duplicates). This was a 58% success rate.

The data supplied by all organisations identified in **Scotland heat map user guide –** 2.2 metadata, limitations and data management was organised into a consistent table structure. In some cases the data required conversion to match the correct units in the field headings (i.e. conversion of MWh to kWh, etc). Additional analysis was undertaken on some of the datasets to interpret the heat generation potential from other data.

3.11.2 Data Sources

Potential energy supply data sources include National and local authority data. National data is available from:

- Coal Authority
- DECC CHP Focus
- Energy Savings Trust
- Forestry Commission
- Heat Network Partnership
- DECC - RESTATS
- Ofgem
- Scottish Water
- SEPA
- Scotch Whisky Association
- WRAP

In cases where heat supply records are duplicated, the matching records have been merged and one record removed. It is accepted that not all duplicates will be detected due to small variation in address fields and therefore there is some duplicate information. In these cases both records are retained in the map to provide the most complete set of information. Further research can be undertaken on heat supply locations and duplicates can be cleaned in due course.

The following local authorities were able to provide cooling tower data:

- Aberdeen City Council
- Aberdeenshire Council
- Angus Council
- Argyll and Bute
- Clackmannanshire Council
- Comhairle nan Eilean Siar
- Dumfries and Galloway
- Dundee
- East Lothian
- Falkirk
- Fife
- Glasgow
- Inverclyde
- Moray Council
- North Ayrshire
- North Lanarkshire
- Orkney Islands
- Scottish Borders
- South Ayrshire
- Stirling
- West Dunbartonshire Council

It should be noted that some local authorities do not have cooling towers and therefore no data will be available.

The organisation numbers allocated to the providers of energy supply data are listed below.

Table 14: List of supply data providers and corresponding ORG_NO

ORG_NO	Data Source
1	Aberdeen City Council
2	Aberdeenshire Council
3	Angus Council
4	Argyll and Bute
6	Clackmannanshire Council
128	Coal Authority
32	Comhairle nan Eilean Siar
141	DECC CHP Focus
8	Dumfries and Galloway
9	Dundee
12	East Lothian
126	Energy Savings Trust
15	Falkirk
16	Fife
129	Forestry Commission
17	Glasgow

ORG_NO	Data Source
134	Heat Network Partnership
19	Inverclyde
21	Moray Council
132	DECC - RESTATS
22	North Ayrshire
23	North Lanarkshire
24	Orkney Islands
131	Ofgem
5	Scottish Borders
127	SCOTTISH WATER
125	SEPA
28	South Ayrshire
30	Stirling
130	Scotch Whisky Association
7	West Dunbartonshire Council
133	WRAP

The sources of data are held in various structures with different metadata assigned. The [HEAT_SUPPLY] database has been developed as a standard attribute table which forms the template metadata format. The initial step in processing incoming data requires it to be converted into an identical format. The data structure for the heat supply layer is included in **Scotland heat map - user guide** 2.2 Metadata, limitations and data management.

The heat supply layer is shown as a point layer with associated attributes including information on the `Heat_Supply_Capacity`, `Primary_Technology`, `Fuel_Source` and `Operator`.

3.12 District Heating Networks

The sources of heat network data include:

- network owners
- HNP
- EST

The geodatabase includes existing and proposed district heating networks in Scotland. The datasets comprise the following layers:

- point layer, which indicates the location of energy centres or buildings/ estates connected to district heating networks
- polyline layer, which includes pipeline routes
- table with proposed new networks for which location data is not available.

Data has been imported from multiple sources with varying accuracy. Point data has been mapped from postcodes, addresses, coordinates or imported from existing shape files. Polylines have been imported from projected AutoCAD drawings, georeferenced maps or from existing shape files.

The attribute table for the district heating database is shown below.

Table 15: Attribute table for the district heating layer

Field	Description
Name	Name of the network/ respective building/ estate
State	Existing/ proposed
Operator	Operator of the network
Local_Authority	Respective local authority
Data_Source	Data source
Source_ID	ID number allocated by the data source
Tech (available for selected point data only)	Technology of the energy centre (e.g. gas/ biomass/ energy from waste etc.)
MWh (available for selected point data only)	MWh generated per year.
Size (available for selected point data only)	Following categories have been used to indicate size: • Less than 500 MWh a year; • 500 MWh to 999 MWh a year • 10,000 MWh a year and above

To help with displaying future proposed and completed district heating on heat maps a specification has been developed. **Scotland heat map – user guide** 2.3 local knowledge, validation & improvement

3.13 Opportunities and Constraints

A series of layers were provided by Historic Scotland and Scottish Government. These are combined in a geodatabase and directly inserted into the heat map. They can be used to identify historical buildings that may contribute as significant heat demands.

The Scottish Index of Multiple Deprivation (SIMD) is the Scottish Government's official tool for identifying those places in Scotland suffering from deprivation. It incorporates several different aspects of deprivation, combining them into a single index. The SIMD provides a relative ranking for each data zone, from 1 (most deprived) to 6,505 (least deprived). By identifying small areas where there are concentrations of multiple deprivation, the SIMD can be used to target policies and resources at the places with greatest need.

In addition this layer contains planning information relating to historic buildings and monuments and conservation areas. There other environmental constraints maps can be overlaid on the map to assist with identification of planning constraints arising from environmental or building conservation restrictions.

The layers within this geodatabase are as follows:

- Historic Scotland
- Conservation Areas
- Scottish Index of Multiple Deprivation
- Surface Water Features will be made available through the Ordnance Survey Address Base product

3.14 Layer Options

The ability to divide the heat map up using a variety of boundaries enables the presentation and analysis at different scales relevant to projects. The following areas are identified at decreasing sizes:

- Scottish national boundary
- Local authority areas
- Data Zones
- Post Codes
- settlement area polygons

3.15 Additional Information

Additional layers could be gathered for future versions of the heat map. These often cross local authority boundaries. Options for sharing data across local authority boundaries are being considered and will be explored. Potential wider boundaries could include:

- community plan partnership
- health board
- strategic development plan boundaries

3.16 Utilities Layouts

SGN has provided gas pipe layouts at transmission and distribution level. These pipe shape files are available separately to local authorities by agreement with Scotia Gas Networks. Scottish and Southern Energy have provided electricity infrastructure for analysis by Scottish Government.

Information will be sought from other utility companies for future development of the heat map. This information is very useful for strategic planning purposes relating to heat recovery and decentralised energy masterplanning.

4. Heat demand calculations

This section outlines the calculations and queries which must be carried out on the data sets to produce the final results to be illustrated by the heat map.

4.1 Address Matching

Where UPRNs are not provided, point data can be mapped by matching the address fields to those in the AddressBase.

Queries should be run to match various combinations of address properties such as `PAO_START_NUMBER`, `THOROUGHFARE_NAME` and `POSTCODE`. Examples are as follows:

/* Match with PAO start number, thoroughfare name and postcode */

```
UPDATE        ACTUAL_HEAT_DEMAND
SET                 UPRN2 = AddressBasePlusData.UPRN
FROM             ACTUAL_HEAT_DEMAND INNER JOIN
                          AddressBasePlusData ON
ACTUAL_HEAT_DEMAND.PAO_START_NUMBER =
AddressBasePlusData.PAO_START_NUMBER AND
                          ACTUAL_HEAT_DEMAND.THOROUGHFARE_NAME
= AddressBasePlusData.THOROUGHFARE AND
                          ACTUAL_HEAT_DEMAND.POSTCODE =
AddressBasePlusData.POSTCODE
WHERE         (ACTUAL_HEAT_DEMAND.UPRN2 IS NULL)
```

/* Match with building name and thoroughfare name */

```
UPDATE        ACTUAL_HEAT_DEMAND
SET                 UPRN2 = AddressBasePlusData.UPRN
FROM             ACTUAL_HEAT_DEMAND INNER JOIN
                          AddressBasePlusData ON
ACTUAL_HEAT_DEMAND.BUILDING_NAME =
AddressBasePlusData.BUILDING_NAME AND
                          ACTUAL_HEAT_DEMAND.THOROUGHFARE_NAME
= AddressBasePlusData.THOROUGHFARE
WHERE         (ACTUAL_HEAT_DEMAND.UPRN2 IS NULL)
```

/* Match with building name and postcode */

```
UPDATE        ACTUAL_HEAT_DEMAND
SET                 UPRN2 = AddressBasePlusData.UPRN
FROM             ACTUAL_HEAT_DEMAND INNER JOIN
                          AddressBasePlusData ON
ACTUAL_HEAT_DEMAND.BUILDING_NAME =
AddressBasePlusData.BUILDING_NAME AND
                          ACTUAL_HEAT_DEMAND.POSTCODE =
AddressBasePlusData.POSTCODE_LOCATOR
WHERE         (ACTUAL_HEAT_DEMAND.UPRN2 IS NULL)
```

In many cases the address properties provided from data sources are not identical to those in the AddressBase and therefore the address matching process will not map all data. Often a significant proportion of records are lost.

4.2 Assigning Benchmarks to AddressBase Data

Calculation Code 1

Two queries must be completed to assign a domestic and non-domestic benchmark.

/* Set benchmark to 247 for the basic master map areas <=200 sqm */

```
Update Heatdemandlyr1
set BM=247
where calccode=1 and MM_Area<=200
```

/* Set benchmark to 220 for the basic master map areas >200 sqm */

```
Update Heatdemandlyr1
set BM=220
where calccode=1 and MM_Area>200
```

The HeatDemand field can then be updated as the product of the benchmark and the calculated floor area:

/* Set heatdemand for basic level, where master map areas are used */

```
update heatdemandlyr1
set HeatDemand=BM*MM_Area
where calccode=1
```

4.3 Assigning Benchmarks to Domestic Assessor Data

The domestic benchmarking process is more complex than for non-domestic buildings as the building age must be taken into account in addition to the building type.

The overall benchmarking process is shown in Figure 6.

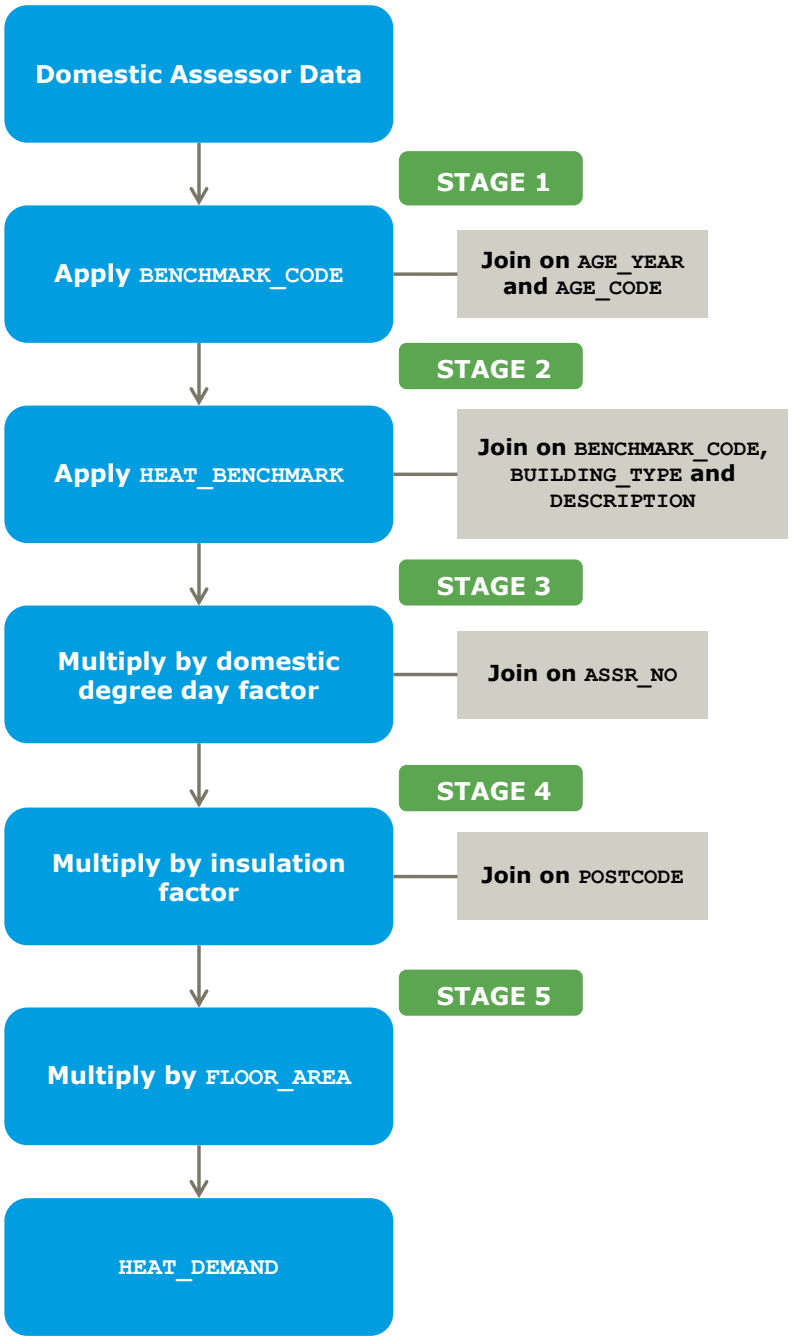


Figure 6: Process for benchmarking domestic Assessor data

Stage 1 is to assign the correct benchmark age code to each record. Assessor data typically contains two indicators of building age: `age_code` and `age_year`. Where the `age_year` field is populated, it should be used to assign the correct `BENCHMARK_CODE` AA – E. This can be done using a series of queries which allocate a code to year depending on whether it is > and < particular boundaries.

Where `age_code` is the only indication of building age, a join must be completed between the `age_code` and lookup table.

Stage 2 is to apply the correct heat benchmark using a join query between the building_type, description and benchmark_code fields in the Assessor data and the benchmark lookup table.

Stage 3 is the application of degree days to the heat benchmark based on location. This is a simple join query based on ASSR_NO.

Stage 4 is the application of the insulation factor. This is a simple join between the postcode and insulation factor lookup table.

Stage 5 is multiplication of the factored heat benchmark (given per m^2) by the building floor area to give the total annual heat demand value.

Where the records lack certain pieces of information that are required to follow the above process, additional calculations must be carried out. These calculations were listed in Section 3.5 and are explained in further detail here.

Calculation Code 5

"Private domestic properties where there is data on age and type, but no floor area".

This calculation code applies to all private domestic properties where information on the building type and age is provided, but there is no value for floor area. In this case an average floor area is applied based on the building type.

There are two possible methods for calculating average floor area: By averaging the remaining records, or by using publicly available national averages. In the case of the Scotland Heat Map publicly available values have been taken.

Table 16: Average floor area per m² for UK house types[6]

House Type	Average Floor Area (m^2)
Detached	143
Semi-Detached	105
Terrace	96
Flat	70

Before calculating the heat demand following the flow diagram in Figure 6, the null floor area values must be replaced by the relevant average using an update query and join with the table above.

As previously emphasised, the data sources will not often use these four house types and it is likely that a more detailed lookup table will have to be created to assign one of the four basic house types to each variation of building description.

Calculation Code 6

[6] Nationwide Building Society figures taken from Scottish Government Guide to Heat Mapping

“Private domestic properties where there is data on age and floor area, but no property type”

This calculation code applies to all private domestic properties where information on the floor area and age is provided, but there is no indication of building type. In this case an average of all four building types is applied for the stated building age.

The process diagram can be followed until stage 2, where an additional update query must be applied to the `heat_benchmark` field in combination with a join to the table below.

Table 17: Average benchmarks for each age code where building type is not provided

Code	Average Benchmark
AA	217
A	217
B	278
C	298
D	318
E	350
AB	247
ABC	264

Once the average benchmark has been assigned the remainder of the domestic benchmark process can be completed as shown in Figure 6.

Calculation Code 7

“Private domestic properties where there is data on property type and floor area, but no age”

This calculation code applies to all private domestic properties where information on the property type and floor area is provided, but there is no information on the property age. In this case an average of all ages is applied for each property type. This corresponds to the benchmark code ABCDE.

Properties containing no age data should be updated using a query which replaces null `benchmark_code` values with “ABCDE”.

Once this code has been assigned the domestic benchmark process can be completed as shown in Figure 6.

Calculation Code 10

“Private domestic property with only floor area provided.”

In this case there are two pieces of information missing from the record age and building type. This calculation code is a combination of both calculation codes 6 and 7 as described previously.

Calculation Code 11

“Private domestic property with only building type known.”

In this case there are two pieces of information missing from the record, floor area and age. This calculation code is a combination of both calculation codes 5 and 7 as described previously.

Calculation Code 12

“Private domestic properties where data on age, property type and floor area is available.”

In this case all relevant information is available and the process in Figure 6 can be followed easily.

Calculation Code 3

“Private domestic properties where data exists which categorises the property as domestic, but no other information is available.”

In this case a record exists within the private domestic data which states the address, but there is no information of age, property type or floor area.

This requires the application of codes 5, 6 and 7.

4.4 Assigning Benchmarks to Non-Domestic Assessor Data

The overall process for non-domestic benchmarking is shown in the following flow diagram:

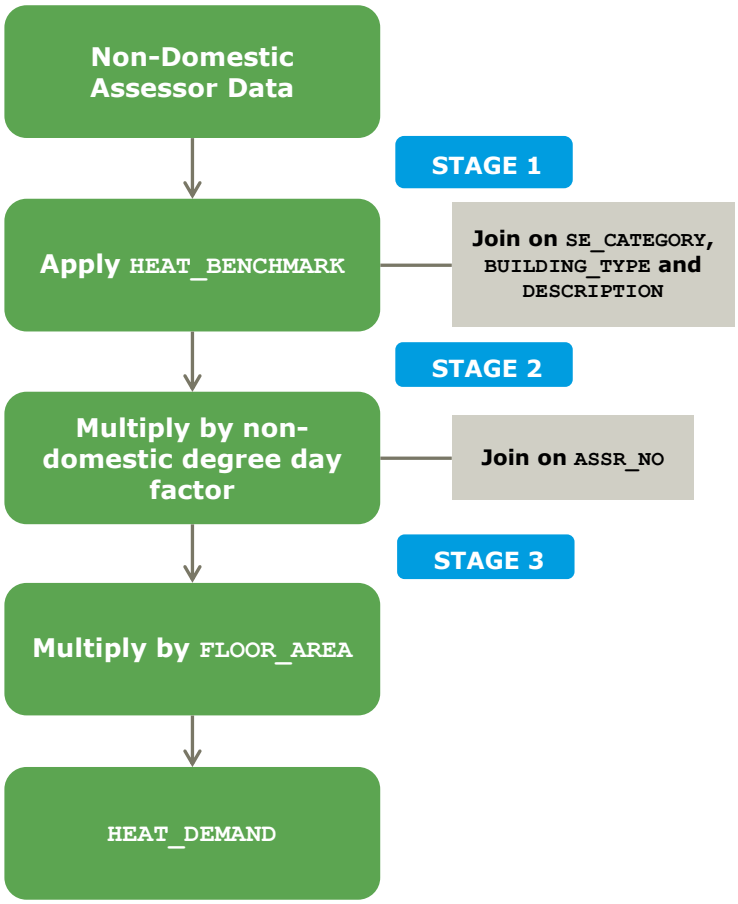


Figure 7: Non-domestic property benchmarking process

The calculation of heat demand is largely the same for non-domestic Assessor data and ePIMS data. As age is not considered to be a factor for the benchmarking of non-domestic properties there are fewer stages to the calculation.

Stage 1 is to apply the correct heat benchmark using a join query between the `building_type`, description and `SE_Category` fields in the Assessor data and the benchmark lookup table.

Stage 2 is the application of degree days to the heat benchmark based on location. This is a simple join query based on `ASSR_NO`.

Stage 3 is multiplication of the factored heat benchmark (given per m^2) by the building floor area to give the total annual heat demand value.

Similarly to the domestic data, where the records lack certain pieces of information that are required to follow the above process, additional calculations must be carried out. These calculations were listed in Section 0 and are explained in further detail here.

Calculation Code 8

“Private non-domestic properties where there is data on floor area, but building type is unavailable.”

Where there is no indication of building type to enable a join in Stage 1 of the process in Figure 7, `HEAT_BENCHMARK` should be updated to the average of all non-domestic benchmarks presented in Table 11. This is calculated to be approximately **194 kWh/m^2/yr**.

Calculation Code 9

“Private non-domestic properties where there is data on property type, but floor area is unavailable.”

There is great variation between the possible floor areas within a set building type. For example, an “office” can be a set of small rooms within a larger complex, or an entire multi-storey building. Therefore it is not appropriate to use averages in this case. Non-domestic properties which do not have an assigned floor area are not included in the heat map.

Calculation Code 13

“Private non-domestic properties where data on property type and floor area is available”.

In this case all relevant information is provided and the calculations can be carried out in accordance with Figure 7.

Calculation Code 2

“Private non-domestic properties where data exists which categorises properties as non-domestic, but no other information is available.”

As with Calculation Code 9, there is no floor area provided in this case and therefore the records are excluded.

4.5 Assigning Benchmarks to Non-Domestic ePIMS Data

The ePIMS data is largely similar to the non-domestic Assessor data with the exception that the records are public buildings, rather than private.

The calculation process is the same as that for non-domestic assessors with the exception that:

- the Stage 1 join is matched on `BUILDING_TYPE` and `DESCRIPTION` only
- the Stage 2 join is matched on `POSTCODE`.

Calculation Code 4

“Public non-domestic properties where data exists which categorises the property as public non-domestic, but no other data exists.”

In this case none of the relevant attribute data is provided and, as with the non-domestic Assessors, no averages will be applied. This results in no heat demand being included in the Scotland Heat Map for these records.

Calculation Code 14

“Public non-domestic properties where data on property type and floor area is available.”

In this case all relevant information is available to work through the calculations.

4.6 Distilleries

Calculation Code 16

The ScotchWhisky.net website provided volumetric production capacities for each distillery indicated on the map. Specific energy consumption benchmarks where applied to the production capacities to estimate the annual energy demand of each distillery. The benchmark value of 8,300 MWh/Mlitres capacity was calculated based on known heat demand for selected distilleries from work undertaken by Resource Efficient Scotland. This was reviewed and then used as a proxy for metered heat demand.

4.7 Public Sector Heat Demand Data

The public sector heat demand data most often contains the fuel use rather than heat demand; therefore calculations are required to convert the data before it can be mapped.

Figure 8 illustrates the process which must be applied to the fuel consumption values.

This process corresponds with calculation codes 17 and 18.

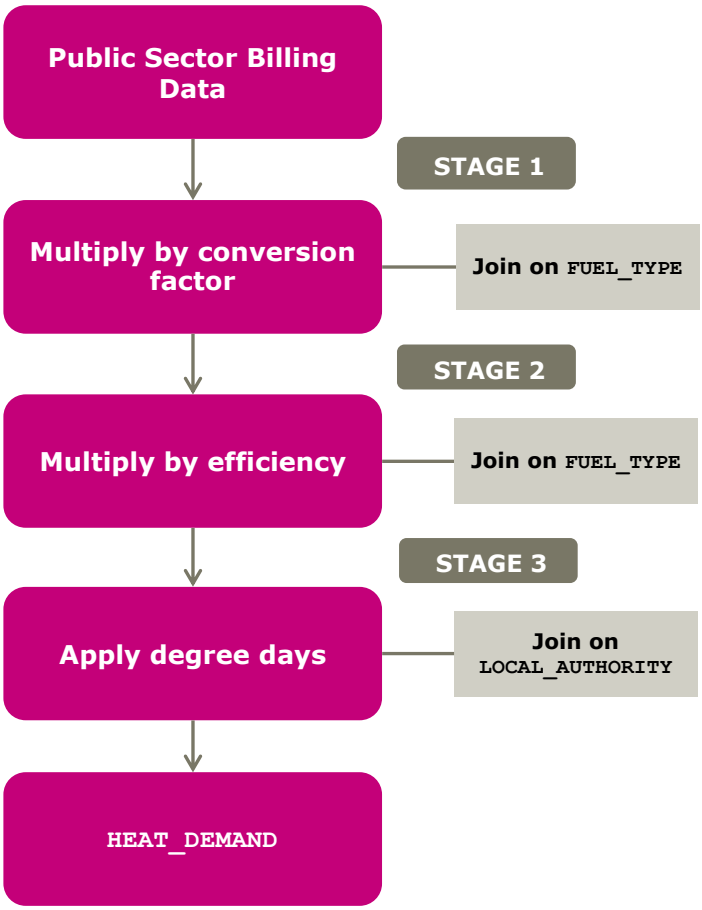


Figure 8: Calculation process for public sector billing data

4.8 Future Heat Demand

In order to identify future heat demand potential in the heat map a benchmark value has been assigned to Housing Land Allocation figures provided by Local Authorities in each development area. The heat demand benchmark for new buildings has been estimated using the following methodology:

1. Property floor area is based on an average of all properties across the SHCS:
   89.4 m²/dwelling
2. Average heat demand is based on an average of benchmark code A for all building types:
   217 kWh/m²/annum
3. Assuming the heat and DHW demand associated with the requirements of Building Standards reductions in building emissions rate (BER) for non-domestic properties reduces at the same rate as for domestic properties then the reduction is expected to be:
   59%[7]
4. Hence projected heat demand per dwelling is assumed to be:
   11,375 kWh/annum

[7] Based on 43% scenario identified in Annex E of the report titled, "Assessing the Cost Impact of Potential Improvements to Energy Standards for New Buildings within Building Regulations" (AECOM, 2011)

4.9 Energy Supply Data

4.9.1 Waste to energy plants

SEPA also provided a collated set of information from the heat plans submitted to them for existing and proposed waste to energy plants. This information was converted into the appropriate database field structure and included within the heat supply database.

4.9.2 Wastewater Treatment Works (WWTW)

Effluent flow figures provided by Scottish Water from WWTW sites are converted into an estimated heat availability. This is based on a calculation of the heat potential based on dry weather flows, effluent temperature and allowable temperature drop across the heat pump.

The steps involved in estimating the heat available from WWTW sites is explained in Figure 6. Steps 1 and 2 relate to the gathering of the required information in order to undertake the analysis. Step 3 calculates the heat capacity in the effluent based on recovering heat from effluent and discharging to the water body at 3ºC[8] above or below the water body temperature as required by SEPA. Step 4 then assigns an enhancement to the capacity as a result of the use of a heat pump as the means of recovering heat.

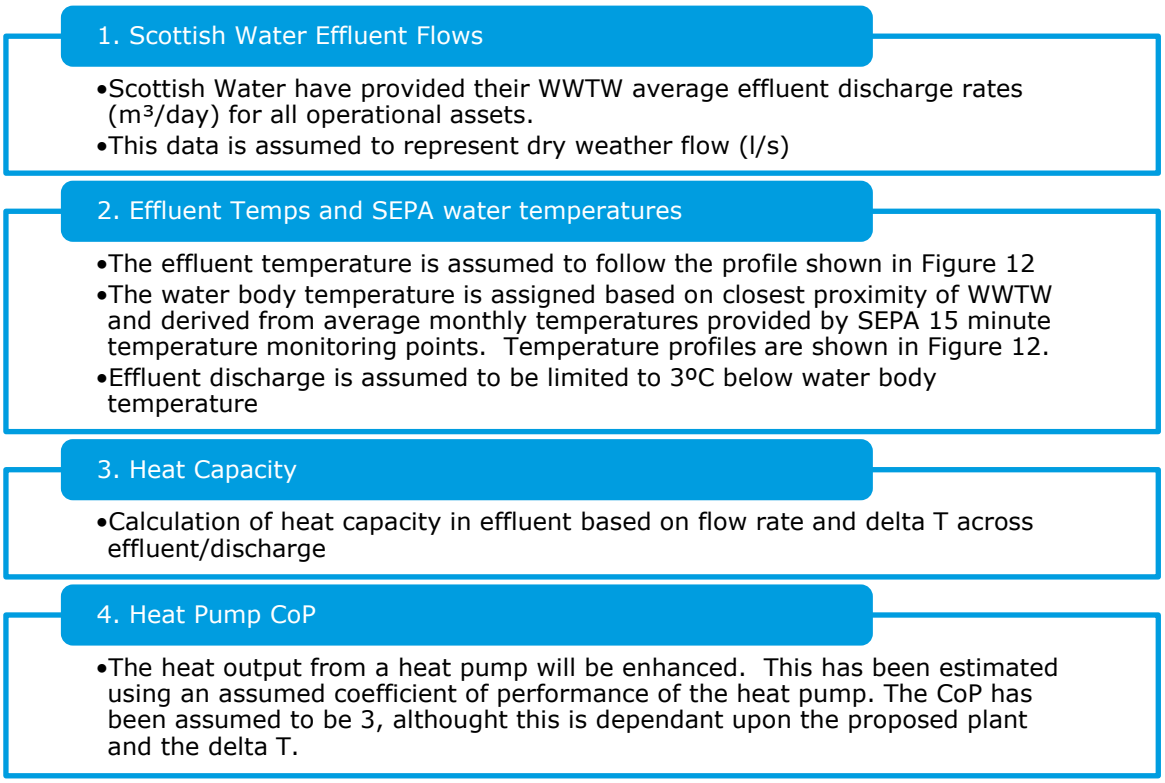


Figure 1: Calculation steps to estimate WWTW heat capacity

[8] this figure was agreed with SEPA as a suitable basis for the analysis but detailed proposals should be submitted to SEPA for approval

	Typical Heat Pump Sc		20										
		January	February	March	April	May	June	July	August	September	October	November	December
	COP (85°C HW) before	N/A	N/A	N/A	N/A	N/A	N/A	2.2519885	2.2995504	2.3237067	2.2519885	N/A	N/A
	COP (85°C HW)	N/A	N/A	N/A	N/A	N/A	N/A	2.761263	2.8088248	2.8329811	2.761263	N/A	N/A
	COP (70°C HW) before	2.838440448	2.897229	2.9572352	3.0495827	3.1448141	3.2764311	3.4135567	3.4842568	3.5201541	3.4135567	3.1772142	2.897229
	COP (70°C HW)	3.347714934	3.4065035	3.4665096	3.5588572	3.6540885	3.7857056	3.9228312	3.9935313	4.0294286	3.9228312	3.6864886	3.4065035
	COP (55°C HW)before	3.7544	3.8631	3.9704	4.128725	4.2839	4.4859	4.6823	4.7784	4.825925	4.6823	4.334925	3.8631
	COP (55°C HW)	4.263674487	4.3723745	4.4796745	4.6379995	4.7931745	4.9951745	5.1915745	5.2876745	5.3351995	5.1915745	4.8441995	4.3723745
	COP (40°C HW)before	5.1226	5.2244	5.3352	5.518275	5.7216	6.0242	6.3628	6.5456	6.640375	6.3628	5.793875	5.2244
	COP (40°C HW)	5.631874487	5.7336745	5.8444745	6.0275495	6.2308745	6.5334745	6.8720745	7.0548745	7.1496495	6.8720745	6.3031495	5.7336745
Sea, St Andrews			31	59	90	120	151	181	212	242	273	304	334	365
	Units	Month												
		January	February	March	April	May	June	July	August	September	October	November	December
Days			31	28	31	30	31	30	31	30	31	31	30	31
Hours			744	672	744	720	744	720	744	720	744	744	720	744
Temp Effluent	ºC		7	8	9	10.5	12	14	16	17	17.5	16	12.5	8
Temp River	ºC		7.5	6.8	6.6	7.2	9.2	11.5	13.5	14.1	13.3	12.2	10.8	9.1
Temp Discharge	ºC		4.5	3.8	3.6	4.2	6.2	8.5	10.5	11.1	10.3	9.2	7.8	6.1
Delta T	K		2.5	4.2	5.4	6.3	5.8	5.5	5.5	5.9	7.2	6.8	4.7	1.9
Heat Abstraction Capacity	J/g		10.5	17.6	22.6	26.4	24.3	23.0	23.0	24.7	30.1	28.5	19.7	7.9
Heat Abstraction Capacity	kWh/m³/h		2.9	4.9	6.3	7.3	6.7	6.4	6.4	6.9	8.4	7.9	5.5	2.2
Delivered Heat Capacity	kWh/m³/h		4.1	6.9	8.8	10.2	9.3	8.7	8.6	9.1	11.1	10.6	7.5	3.1
Monthly Heat Capacity	kWh/m³	3082.515197	4643.336	6562.442	7332.073	6904.843	6254.549	6382.939	6586.383	8280.897	7891.634	5396.938	2325.616	

Figure 2: Example of calculation for annual heat capacity of a WWTW with discharge to sea

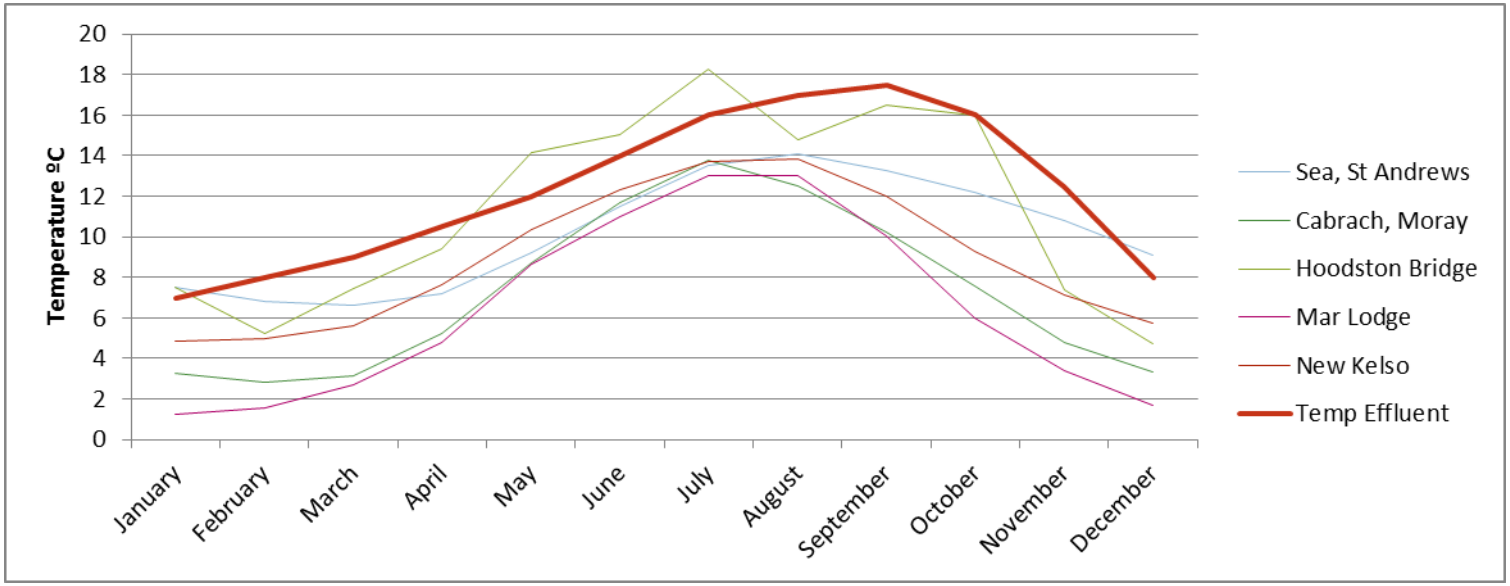


Figure 3: Water body temperatures (courtesy of SW and SEPA)

4.9.3 Heat generation from Coal Authority

Data has been made available by the Coal Authority on historical mining locations and minewater treatment sites. The locations of minewater treatment sites are identified as point references in the heat map.

The Coal Authority make their GIS mapping data available as web mapping services (WMS) as defined in **Scotland heat map user guide –** 2.2 metadata, limitations and data management. This is an open format that is linked to the heat map through the hosted GIS software. The following layers are included as external links embedded in the heat map:

- Development risk and coal resource areas indicate locations of former mining activity;
- Mine entries - contains the centre point of a mine shaft, a vertical or near vertical entrance to a mine, or a centre point of an adit, a walkable entrance to a mine, as shown on plans held by the Coal Authority.

4.9.4 Heat generation from Forestry Commission

The Forestry Commission has provided details of biomass heat generation plant in Scotland as well as polygons indicating forestry areas across Scotland.

The polygons are imported into the heat map as a feature class and included within the energy supply layer.

4.9.5 Heat generation from Scotch Whisky Association (SWA)

A list of whisky distilleries was taken from ScotchWhisky.net including estimates of whisky production at each site. The volume of whisky has been used as a proxy for the total heat generation capacity and demand at the individual distillery. The calculation used is the same as the calculation of heat demand in Section 4.6.

4.9.6 Heat generation from OfGEM

Ofgem's RO/FiT/REGO/CHP databases provide a source of information regarding heat and electricity generation resources across Scotland. The data is not UPRN matched but does include addresses with postcodes which required manual data matching.

5. Create final outputs

5.1 Preparing the GIS Maps

Each data set within the heat map is created as a feature class based on the individual databases. This feature class can be a point, line or polygon. The feature classes are combined into topic based geodatabases that gather multiple layers together.

The Scotland heat map holds data covering the following area and these are fully defined in Scotland Heat Map user guide 2.2 Metadata, limitations and data management:

- OS Mastermap and Addressbase [OSMA members]
- Heat demand
- Assessor and EPC Data
- Actual Energy Demand (Public Sector)
- Heat Demand Layer (combined)
- Tenure
- Energy Supply Layer
- District Heating Networks
- Planning and Economic Development
- Opportunities and constraints
- Layer options
- Additional layers
- Utilities Layout

5.2 Map formatting and iconography

The symbology for the layers is included in Appendix A of this manual.

Table 18: Colour graduations for the heat demand raster

Demand Density	kWh/m²	50m Grid	250m Grid	500m Grid	1km Grid
Low	0 - 10	0 - 25,000	0 - 625,000	0 - 6,250,000,000	0 - 625,000,000,000
Low-Med	10 - 40	25,000 - 100,000	625,000 - 2,500,000	6,250,000,000 - 25,000,000,000	625,000,000,000 - 2,500,000,000,000
Medium	40 - 100	100,000 - 250,000	2,500,000 - 6,250,000	25,000,000,000 - 62,500,000,000	2,500,000,000,000 - 6,250,000,000,000
Med-High	100 - 250	250,000 - 625,000	6,250,000 - 15,625,000	62,500,000,000 - 156,250,000,000	6,250,000,000,000 - 15,625,000,000,000
High	250 +	625,000 - 0	15,625,000 - 0	156,250,000,000 - 0	15,625,000,000,000 - 0

5.3 Distribution of the heat map

5.3.1 Local authority version

The heat map is available to all local authorities by signing the Scotland heat map – framework[9]. As a result of the data sharing agreements that are in place regarding

[9] the agreement between the Scottish Government and Scottish Local Authorities to share the data

some of the information contained within the heat map certain parts of the heat map have not been distributed to local authorities. These are identified in italics below:

- OS Mastermap and Addressbase
- Heat demand
- Assessor and EPC Data
- Actual Energy Demand (Public Sector)
- Heat Demand Layer (combined)
- Tenure
- Energy Supply Layer (*data identified as confidential and Forestry Commission shape files have not been included*)
- District Heating Networks
- Planning and Economic Development
- Opportunities and constraints
- Layer options
- Additional layers
- Utilities Layout *(Scotia Gas Networks data is not included)*

5.3.2 Web version

A web version will be developed and this will provide access to a more limited version of the heat map. It is intended to provide an initial view of the map to a wide range of users who can then approach the local authority to undertake more detailed analysis where opportunities are identified.

The web version will contain the following layers:

- Background map
- Actual Energy Demand (Public Sector)
- Heat demand by Data Zone
- Heat Demand Layer (combined raster)
- Tenure (*census tenure as social rented*)
- Energy Supply Layer (*data identified as confidential and Forestry Commission shape files have not been included*)
- District Heating Networks (*point data is shown and heat network routes have not been included*)
- Planning and Economic Development (*local development plans shown as shape files*)
- Utilities Layout *(Scotia Gas Networks data is not included)*

6. Utilising the heat map

The heat map will be most useful if it is kept updated with new data. In order to achieve this information included in the map will require future updates as new heat generation and demand data is developed. In addition more detailed information on the capacity and locations of heat supply is expected to be available.

The national map will be distributed to Local Authorities so that it can inform heat planning. Some of the key datasets are held at either Local Authority or national level. As such there is a need to coordinate maintenance of the overall system at regular intervals. The heat map will include tools for uploading and validation of new or replacement data.

The heat map has been developed as a partnership of organisations providing data. It will also rely on those with local knowledge to provide additional checking and validating the data. **Scotland heat map – user guide** 2.3 local knowledge, validation & improvement process.

It is expected that Local Authorities will create queries and import other data into their version of the heat map in order to inform local decision making. When updates of the heat map, noted above, are implemented and shared between the national map and Local Authorities it is essential that the functionality is unaffected.

A web interface will be developed as part of a separate commission by Scottish Government. This tool will show selected publicly available data on a web based mapping interface.

The heat map will be of benefit to a number of organisations within the public and private sector. The core data is held within Scottish Government and sub-set of the data will be distributed to all Local Authorities. The principal route for the private sector to access the heat map will be through the web interface. Due to data sensitivity and protection any further detailed analysis on the amalgamated datasets at a building level is governed by limits in **Scotland heat map – user guide** 2.2 metadata, limitations and data management.

6.1 Local Authority Validation and Improvement

As described in the Scotland heat map – user guide 2.3 validation & improvement the heat map has been developed using the most accurate data available at the time of its preparation. Given that we are drawing together a large number of datasets for the first time, with over 3 million data points, it is inevitable that some data will be incomplete or require further validation. The quality assurance of the data is a crucial step and it is intended that, by distributing the heat map to local authorities, there will be a process of further improving the data and updating the heat map.

The Scottish Government has committed to making an initial revision of the heat map and the proposed timeline for that is described in Section 2.4.4 of the Scotland heat map – user guide 2.0 methodology report. The main heat map dataset will be clipped to each local authority area and presented to them for their own use. As a result, it is possible that over time there could be 33 different versions of the heat

map simultaneously in circulation (The Scottish Government will hold the master version). In order to ensure that the quality assurance of the map avoids any loss of data in the following sequence it is essential that users adopt a systematic approach to amending the data:

1. Master heat map generated by The Scottish Government, clipped and distributed to each of the local authorities;
2. Local authority use of the heat map, including the documentation of any data validation and improvement;
3. Local authority present updates to The Scottish Government according to Scotland heat map – user guide 2.3 validation & improvement including recording all changes to databases as instructed;
4. Scottish Government update the master heat map incorporating local authority updates, once again clipped and re-distributed to local authorities.

In order to manage this process we recommend that all changes to the databases are recorded by local authorities. The following section describes how the databases have been structured to ease the process of controlling updates.

The 4 fields listed in Table 19 have been added to the following datasets to allow information to be collected on which records have been changed and why:

- Heat demand
- Heat supply
- District heating networks

All records are by default assigned a value of “0” in the field Update_type in each of the relevant local authority databases. Where changes are made to any records the following fields must be changed as described below:

Update_type: must be assigned an alternative value (1, 2, or 3) from the field options in Table 19.
UpdatedBy: enter the name of the individual amending the data. This will make it easier to follow up any changes should further information or explanation be required.
UpdateExplanation: enter a brief description of the change, explaining the reasoning and the source of the new information.
Version: is intended to reflect the most recent version of the master database on which the local authority datasets are based. Local authorities are not required to update this field.

Table 19: Fields included for data updates

Fields added	Data Type	Field options
Update_type	smallint	0 = None 1 = Delete 2 = Update 3 = New data
UpdatedBy	nvarchar (25)	***NAME***
UpdateExplanation	nvarchar (150)	***DESCRIPTION***
Version	int	201401 [YEAR and VERSION NO.]

Local authorities are advised to submit all data files which include any updates to The Scottish Government according to Scotland heat map – user guide 2.3 validation & improvement. The Scottish Government will assess and undertake a basic quality control[10] of all the local authority updates and incorporate them into the heat map master, which will again can be clipped and re-distributed to local authorities following this period of quality assurance.

It is important to note that the updated data will supersede the previous version and so **any changes that are not assigned the appropriate update identifier may not be updated**.

6.2 Heat map uses

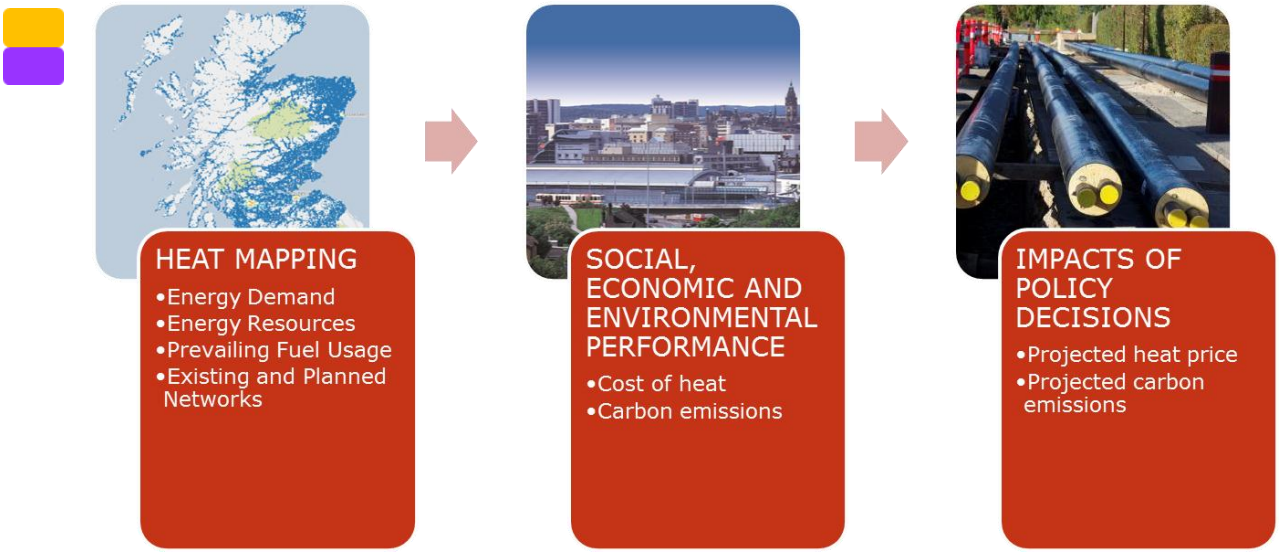
The heat map is based on the best available information and systematic validation of the data. This is not guaranteed to capture all locations of heat generation or demand and some information may contain inaccurate figures. It may be useful to have a tool within the heat map and on the web based system for organisations and individuals to be able to provide feedback where data inaccuracies exist. Any feedback could be reviewed and quality assured before updating the central database.

The heat map is a practical tool which can be used to:

- provide planning authorities with the knowledge base to highlight heat opportunities (such as heat recovery, district heating, renewable heat and low carbon heat) in development plans, in pre-application engagement with developers and in determining planning applications;
- identify projects at a local level and Scotland wide to provide a potential pipeline of projects and the development of local investment proposals;
- support heat plans for commercial and public sector energy management;
- identify heat resources and unused excess heat;
- identify heat opportunities in the domestic sector to benefit social housing and tackle fuel poverty.

[10] The Scottish Government will run a query on all updated data to filter out the records that have been changed and identify any records that have particularly high percentage changes. This will prompt a clarification from local authorities if new data shows a change in heat demand from the original database that falls outside predetermined ranges from the previous value.

6.2.1 National Policy



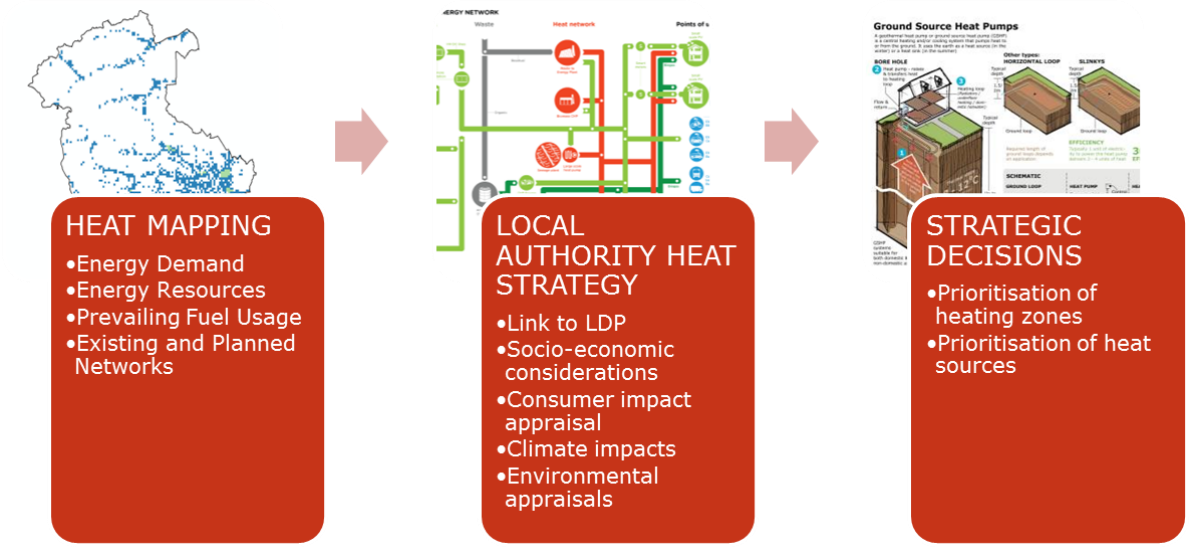
The heat map is a crucial tool in the context of developing a heat strategy and planning for Scotland and will show a national picture of how heat is generated and used. The map can play a fundamental informative and illustrative role in the future evolution of heat policy.

In terms of heat demand the map will show where concentrations of heat exist at a national level and the underlying data will allow simple evaluations of heat density. This can broadly inform policy on where heat networks may be viable or where dedicated heating systems are more appropriate.

The map will be capable of identifying areas where fuel poverty is expected to exist. This could be used to inform policy decisions that address the social and economic impact of decisions affecting heat supply.
The map may also be capable of illustrating the predominating fuels for heating on a national level to inform policy on strategic planning of fuel distribution infrastructure and fuel supply chains. One example of how the map might be used is in determining regional planning areas for biomass, heat pumps, gas network infrastructure or district heating as the primary heat supply.

In terms of heat generation and a transition to renewable forms of heat production the map will be capable of showing all heat production assets at a national level. This will inform the location of additional capacity and could be used, in conjunction with infrastructure planning for electricity generation, to support strategic decisions regarding where to locate cogeneration assets.

6.2.2 Strategic Planning



At a regional planning and Local Authority planning level it is expected that heat mas will play an important role in planning for future infrastructure requirements. The map will show where concentrations of heat demand exist and the general heat density. This can broadly inform local policy on where heat networks may be viable or areas where there may be more demand for individual renewable heat sources.

An ability to overlay local development planning areas on the heat map will illustrate heat network opportunities. This can help to inform public or private sector infrastructure investment plans.

Heat mapping assesses the demand and supplies of heat have been assessed. Knowing where the heat will be consumed and which amount of heat is crucial in a future with sustainable energy planning. By producing the heat near the need, losses can be reduced and make heat distribution more economically feasible. Reduced losses results in less use of fuels (and lower CO_2-emissions in cases where fossil fuel is used). Sustainable energy plans could then inform Local Development Plans.

The map will be capable of identifying areas where fuel poverty is expected to exist. Where possible heat networks should support the goal of reducing fuel poverty. Loal Development which can assist making a connection to a fuel poor area viable could be encouraged by the development plan. This could be used to inform local policy decisions that address the social and economic impact of decisions affecting heat supply.

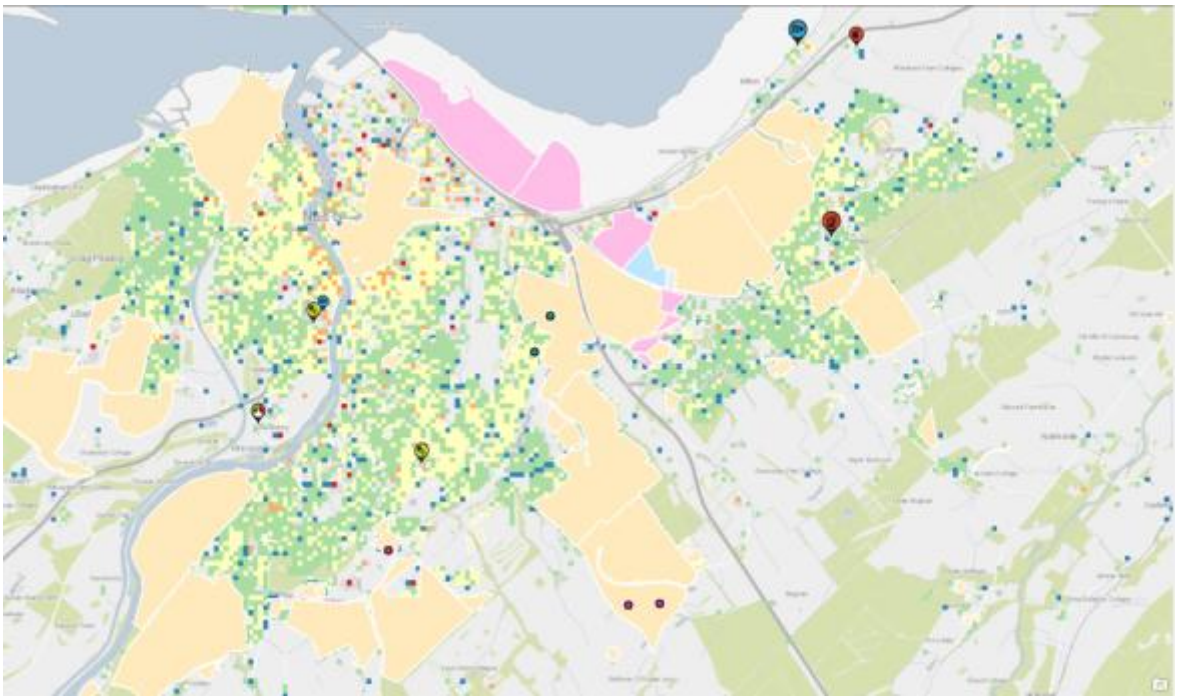


Figure 9: Illustration of heat demand and supply overlay on local authority planning areas

The map may also be capable of illustrating the predominating fuels for heating at a Local Authority level to inform infrastructure planning. Local Authorities may consider assigning heat supply zones based on natural gas, district heating, heat pumps, biomass, etc. Future planning of these zones may consider, for example, installing infrastructure to convert properties with primary fuel supply from the natural gas grid to district heating. Heat zones and policies can become material in development management decision making.

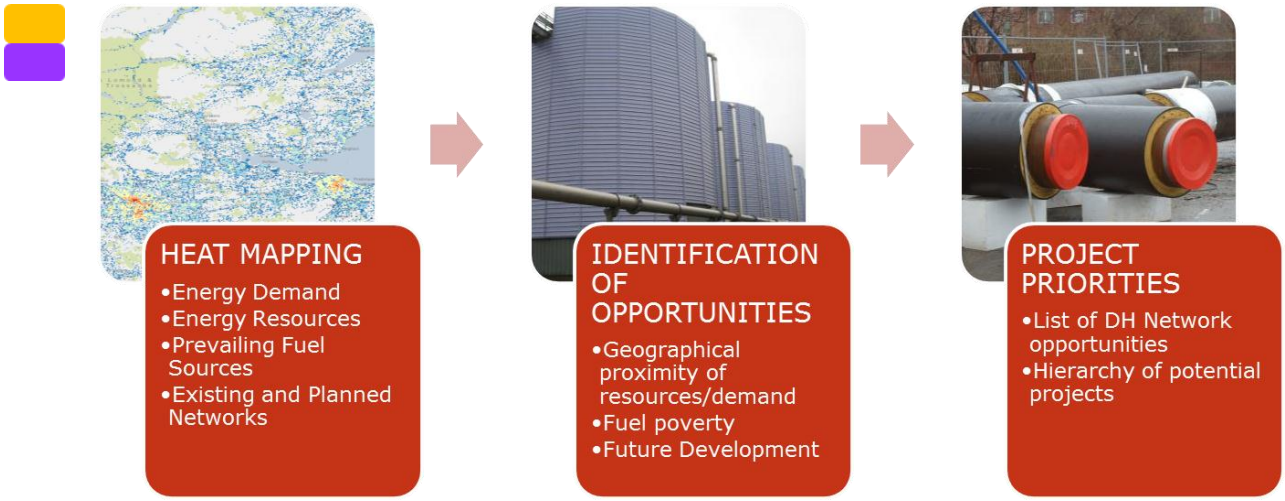
In terms of heat generation and a transition to renewable forms of heat production the map will be capable of showing existing and proposed heat production assets at a regional or Local Authority level. This will inform the planning of additional capacity and could be used, in conjunction with the planning of electricity network infrastructure, to support strategic decisions regarding where to locate cogeneration assets.

Future energy planning may be likely to be conducted in three levels:

- Dense development
- Small urban areas
- Rural areas

They should be treated differently due to the variation in demand density revealed through the heat mapping process. Areas with high heat density are more likely to be feasible for DH, as are some smaller urban areas. In rural areas other approaches and sources of heat may be applicable and more suitable.

6.2.3 Site Identification



Possibly the most pertinent function of the heat map is to identify where heat generation and demand exist in close proximity. The data gathering and cleaning process explains how the map is developed to allow a visual assessment of these opportunities. This may be part of preparing a Local Development Plan[11].

Local Authorities or other public sector organisations may choose to identify potential investment opportunities, for example through the preparation of a Sustainable Energy Action Plan. In addition the private sector may use the web based tool to initially assess opportunities.

It is expected that the site identification stage will involve a visual assessment of opportunity and have limited detailed analysis. This stage would typically comprise a technology options appraisal to assess where there is potential for investment in new technology or integration of existing and planned heat generation and recovery. The suitability of heat technology will depend on a specific set of criteria for each subject site. The following list of technologies may be considered (this list is not exhaustive):-

- Energy efficiency
- Biomass heating
- Combined heat and power
- Heat only boilers
- Capture of waste heat from wastewater, waste to energy or industrial effluent and flue gas emissions
- Biofuel CHP
- Biogas CHP using energy from waste through Anaerobic Digestion
- Solar thermal
- Ground source heat pumps (possibly in combination with wind or PV)
- Deep Geothermal

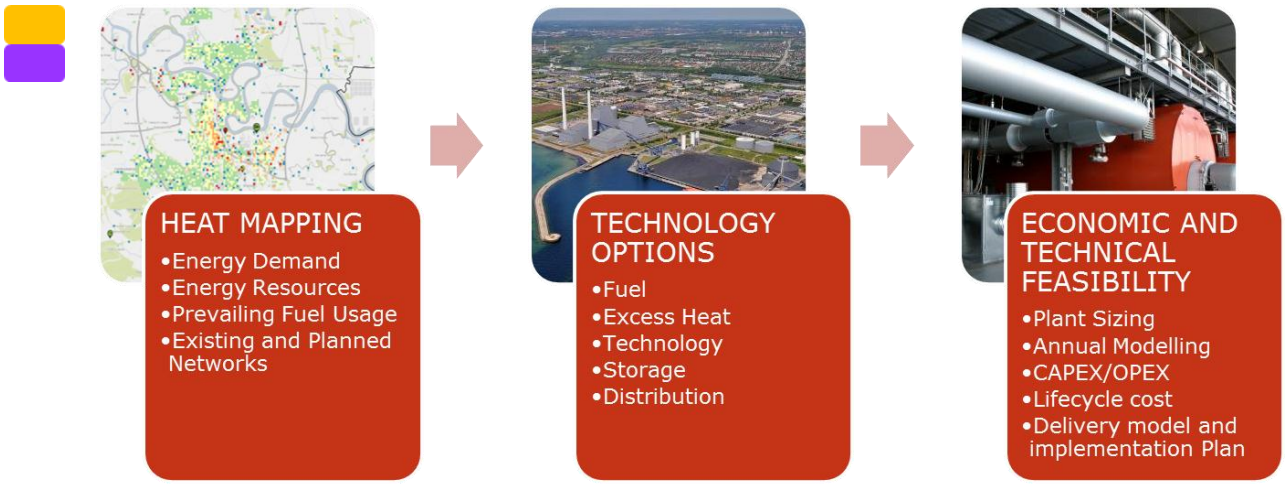
[11] Planning guidance: http://www.scotland.gov.uk/Resource/0042/00423580.pdf

At this stage it is appropriate to identify, screen (and discard as appropriate) options and sub options so that a long list of opportunities can be identified. This long list will be further refined by more detailed feasibility studies explained below.

The screening may include consideration of multiple criteria for evaluation of site and technology options to briefly assess opportunities and barriers for implementation. Other GIS layers may be overlaid at this stage, for example to identify fuel and planning risks. The heat map may assist with consideration of some or all of the following at the initial site identification stage:

- Fuel risk: Current and future local availability and cost of fuel
- Policy compliance: Ability to comply with current and future local, regional and national energy policy and to meet appropriate carbon reduction targets.
- Space requirement: Estimate of relative space requirements considering plant equipment, fuel storage and handling.
- Development and planning policy implications, taking into account barriers to achieving planning approval (notably environmental designated zones, such as air quality, flooding, ecology, etc).

6.2.4 Detailed Feasibility



The site identification stage may generate a large number of opportunities, which can be refined through screening. Selected preferred sites can then be subject to detailed feasibility which will involve a more rigorous technical and economic appraisal of a proposed energy system.

The heat map can provide the primary dataset for the feasibility by identifying heat demand at an individual property level. Many data sets have limitations for public access, for example the assessor data can only be provided at a 50m grid. Data protection will be an important feature at this stage and sharing of individual property data, and other potentially sensitive data, with third parties will not be possible.

The feasibility study will review existing heat demand and introduce future demand from planned development. Peak and diversified demands will be assessed based on typical profiles for different property types. Time domain information to illustrate annual and daily demand profiles may be beneficial but is not within the scope of the current project.

For new developments, demand and annual consumption data will be calculated and the development phasing will be an important aspect of the technical and economic model. The GIS tool could be refined on a project basis to include projected developments (although it is cautioned against publishing future demand in the national heat map).

The heat map can be used to provide details, including plant operator contact details for existing generation potential. The feasibility study will need to assess the viability of heat off-take in greater detail. The heat map will also illustrate other potential available energy resources such as geothermal and biomass fuel resources. In addition other GIS data overlays may be used to identify solar or wind resources but are not within the scope of this heat map.

Integration of the GIS map with hydraulic pipe modelling software may be attractive – this is not within the scope of this study and could be developed by software developers.

The feasibility study will typically be developed to present a technical and economic model for the network, along with carbon savings to support an outline business case.

Where feasibility studies conclude that a project is viable and the project reaches a determined stage of project development (i.e. planning permission) then the national map should be updated to show planned (and subsequently completed) network layouts.

6.3 Summary of Tools

The following tools are discussed in the previous sections and have been summarised in Table 20.

Table 20: Summary of proposed heat map tools

Tool Use	Organisations	Purpose	Heat Map Tools
Maintenance of Heat Map	Scottish Government/Local Authorities	Upload/replacement of data	Upload new or replacement data and validation
Maintenance of Heat Map	Scottish Government/Local Authorities	Heat map updates	Heat map version control and distribution of updates
Presentation	Public	Present the map to private organisations and the public	Web interface to be developed (under separate commission)
Maintenance of Heat Map	Scottish Government/ Public	Improve accuracy of data held in the heat map	Web tool to provide feedback and improve accuracy of the data (under separate commission)
Heat Policy	Scottish Government	Illustrate heat density	Heat demands mapped at 1km grid to show heat density at national level
Heat Policy	Scottish Government	Illustrate areas where fuel poverty may exist or where ECO funding may be available	Fuel poverty indicated by SIMD data. Housing tenure also provides information on where Local Authority or RSL housing exists
Heat Policy	Scottish Government	Illustrate fuels for heating	Primary heating fuel, where available for properties, to be developed as overlay
Heat Policy	Scottish Government	Illustrate heat generation assets	All heat (and electricity) generation plants will be identified
Strategic	Local Authority	Illustrate heat	Heat demands mapped at

Tool Use	Organisations	Purpose	Heat Map Tools
Planning		density	50m, 250m, 500m and 1km grid to show heat density at Local Authority level
Strategic Planning	Local Authority	Overlay local development plan	The Local Authority LDP planning layer will be available as an overlay
Strategic Planning	Local Authority	Illustrate areas where fuel poverty may exist or where ECO funding may be available	Fuel poverty indicated by SIMD data. Housing tenure also provides information on where Local Authority or RSL housing exists
Strategic Planning	Local Authority	Illustrate fuels for heating	Primary heating fuel, where available for properties, to be developed as overlay
Strategic Planning	Local Authority	Illustrate heat generation assets	All heat (and electricity) generation plants will be identified
Site Identification	Local Authority/ Investor	Identify density of heat demand	Heat demands mapped to resolution of individual properties and 50m, 250m, 500m and 1km grid.
Site Identification	Local Authority/ Investor	Estimate annual heat demand within user defined area	Polygon tool surrounding area of interest returning total heat demand within
Site Identification	Local Authority/ Investor	Illustrate locations of existing heat generation	Heat generation sites mapped and existing heat capacity identified
Site Identification	Local Authority/ Investor	Illustrate locations of planned heat generation	Heat generation sites mapped and potential heat capacity identified
Site Identification	Local Authority/ Investor	Fuel supply overlay	Overlay of gas network, biomass fuel supply, geothermal potential
Site Identification	Local Authority/ Investor	Identify planning designations as GIS overlays	Heat map supplied to Local Authorities in suitable format for compatibility with other GIS systems.
Detailed feasibility	Investor	Identify density of existing heat demand	Heat demands mapped to resolution of individual properties and 50m, 250m, 500m and 1km grid
Detailed feasibility	Investor	Allocate future development zones	Bespoke version of GIS heat map developed on a

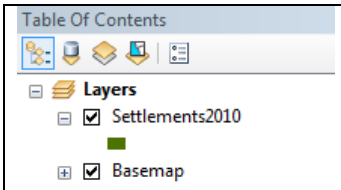
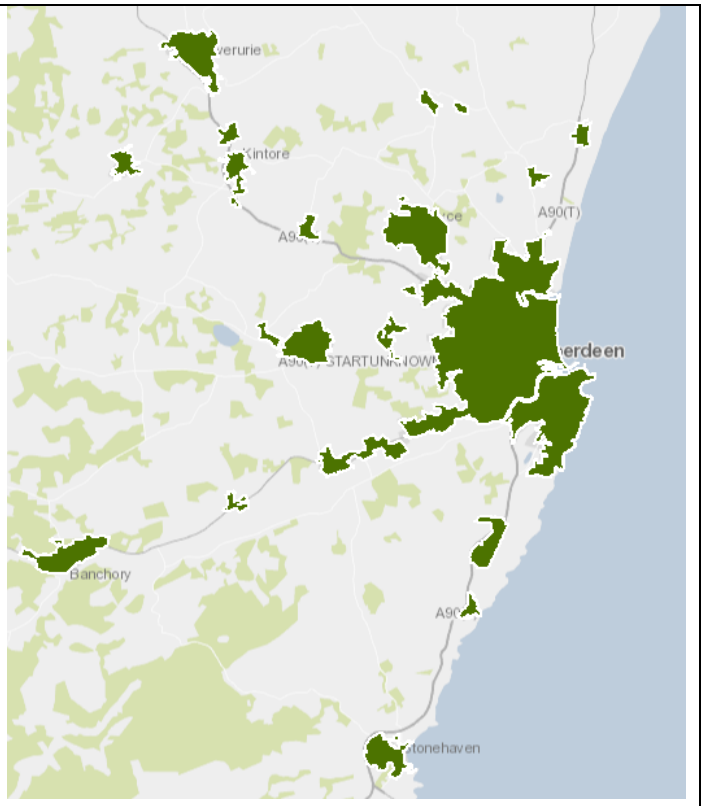
Tool Use	Organisations	Purpose	Heat Map Tools
		and predicted heat demand	project basis to include projected development
Detailed feasibility	Investor	Identification of daily and annual heat demand profiles	OUTSIDE SCOPE: Presentation of demand profiles based on benchmarks for different property types
Detailed feasibility	Investor	Estimate annual heat demand within zones defined area	Polygon tool surrounding area of interest returning total heat demand within
Detailed feasibility	Investor	Illustrate locations of existing heat generation	Heat generation sites mapped and existing heat capacity identified, contacts for plant operator provided where available
Detailed feasibility	Investor	Illustrate locations of planned heat generation	Heat generation sites mapped and potential heat capacity identified, contacts for plant operator provided where available
Detailed feasibility	Investor	Fuel supply overlay	Overlay of gas network, biomass fuel supply, geothermal potential
Detailed feasibility	Investor	Identify planning designations as GIS overlays	Heat map supplied to Local Authorities in suitable format for compatibility with other GIS systems.
Detailed feasibility	Investor	Integration of the GIS map with hydraulic pipe modelling software	OUTSIDE SCOPE: could be developed by software developers
Detailed feasibility	Investor	Update maps with new planned networks	Method of updating heat map with new planned networks that are taken forward following detailed feasibility

APPENDIX A
HEAT MAP STYLES

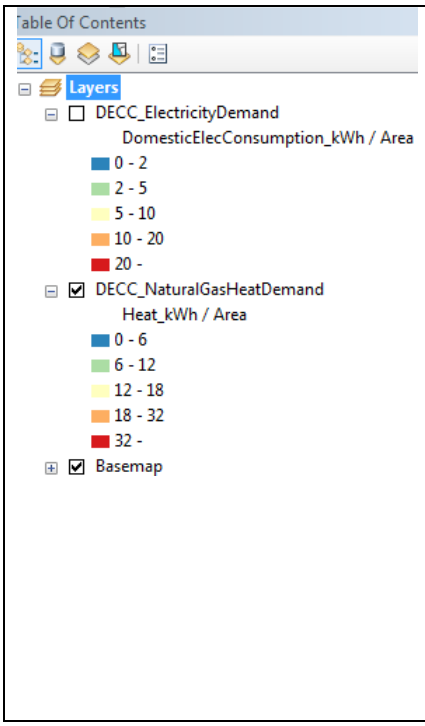
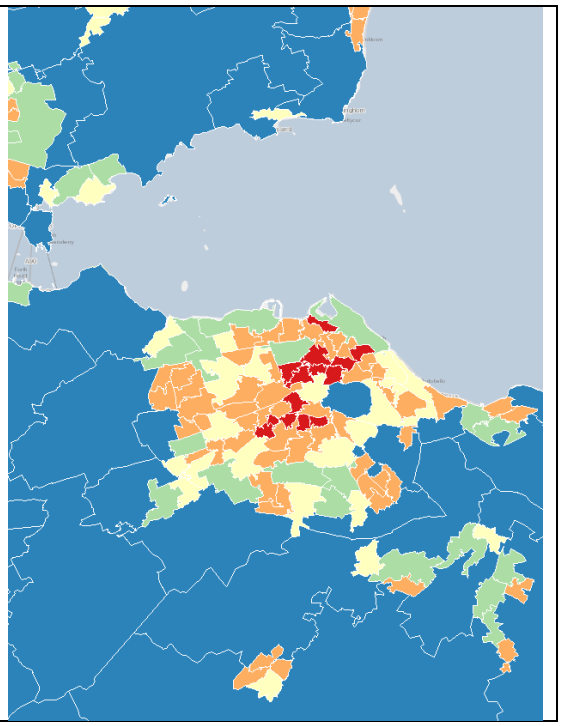
The heat map styles are illustrated in the following Appendix to describe the colours, symbols and icons used in the heat map. The colours were chosen to display as clearly as possible and to be accessible to colour blind and to be print friendly. References are included to link each of the styles back to the relevant page in the document describing how the layer is calculated.

The complexity of the data has been reflected by choosing appropriate symbols to differentiate heat supply and demand. Heat supply is denoted as an inverted teardrop and heat demand as colour coded circles.

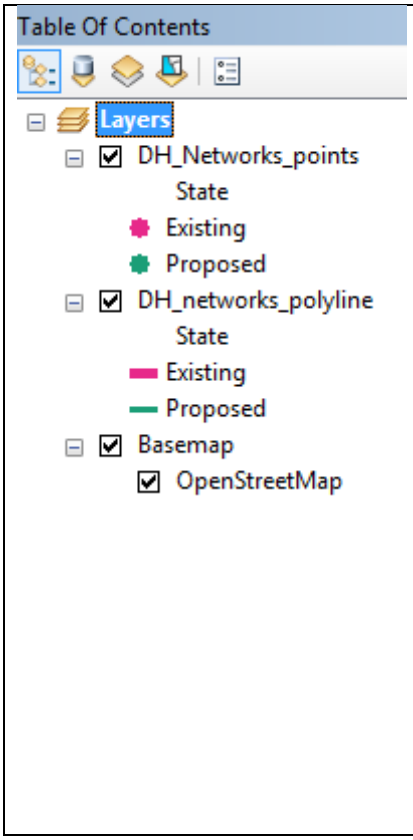
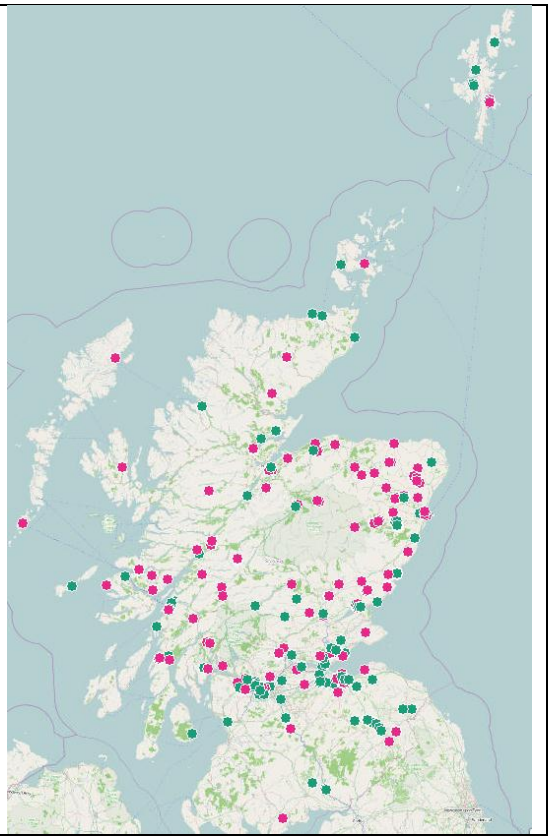
Additional Layers (refer to p. 29)

	RGB (76,115,0)	

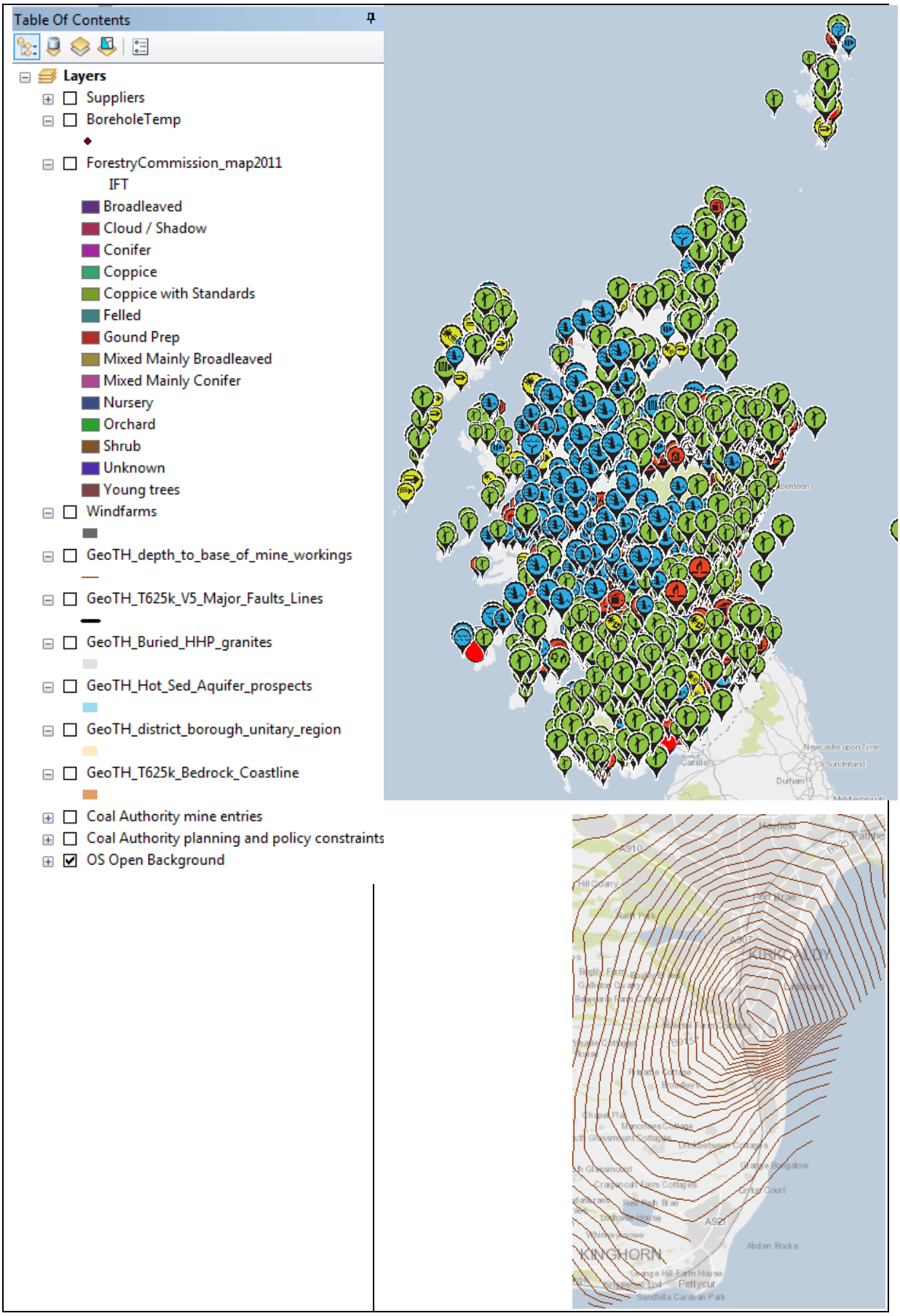
DECC

	RGB Blue (43,131,186) Green (171,221,164) Yellow (255,255,191) Orange (253,174,97) Red (215,25,28)	

District heating networks (refer to p. 27)

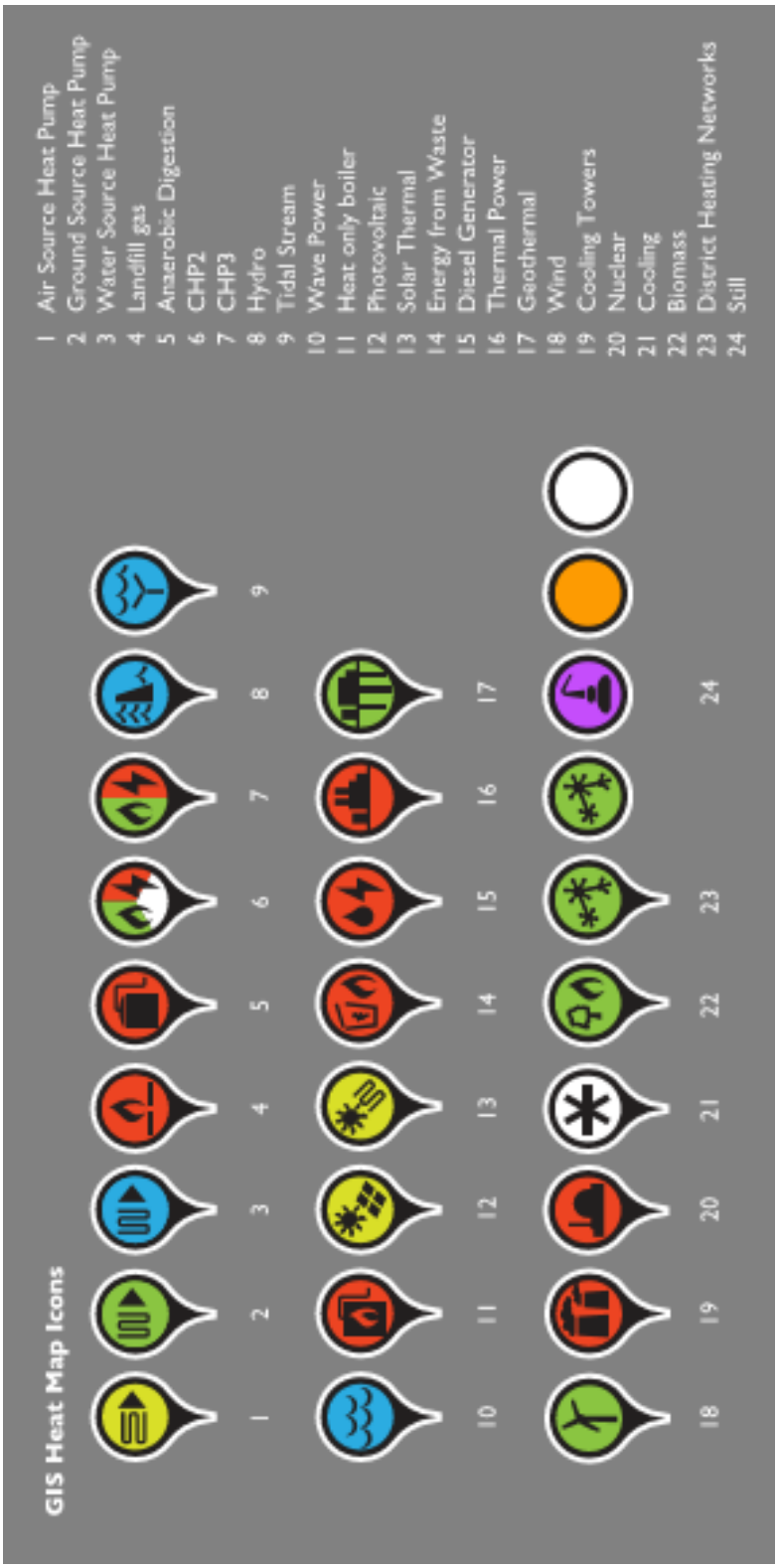
	RGB Red (231,41,138) Green (27,158,119)	

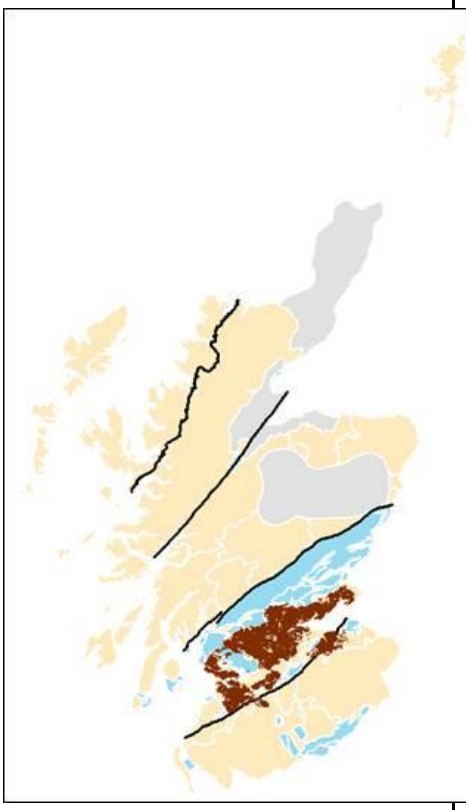
Energy Supply (refer to p. 24)



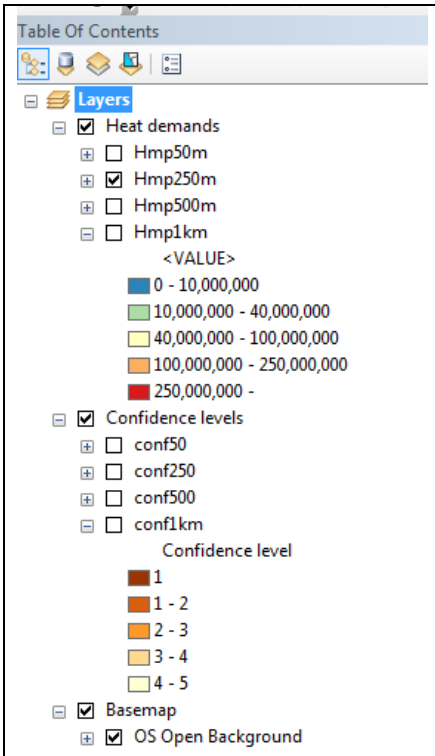
The heat supply is denoted as an inverted teardrop and the colours denote the following:

- Yellow represents energy derived from solar sources
- Green represents energy derived from the ground
- Blue represents energy derived from water
- White represents cooling
- Red represents energy derived from combustion or nuclear



Heatmap layers DistrictHeating DECC EnergySupply Suppliers Suppliers BoreholeTemp ForestryCommission_map2011 Windfarms GeoTH_depth_to_base_of_mine_workings GeoTH_T625k_V5_Major_Faults_Lines GeoTH_Buried_HHP_granites GeoTH_Hot_Sed_Aquifer_prospects GeoTH_district_borough_unitary_region GeoTH_T625k_Bedrock_Coastline Coal Authority mine entries Coal Authority planning and policy constrai OpportunitiesAndConstraints OpportunityAreas Tenure Utilities DataZoneSummaryHeatDemand Layer options AdditionalLayers Heat demand Basemap	RGB Brown (130,46,0) Black (0,0,0) Grey 10% (225,225,225) Blue (151,219,242) Sand (255,234,190) Light brown (222,158,102)	

Heat demand (refer to p. 12)



RGB

Blue
(43,131,186)
Green
(171,221,164)
Yellow
(255,255,191)
Orange
(253,174,97)
Red
(215,25,28)

(153,52,4)
(217,95,14)
(254,153,41)
(254,217,142)
(255,255,212)

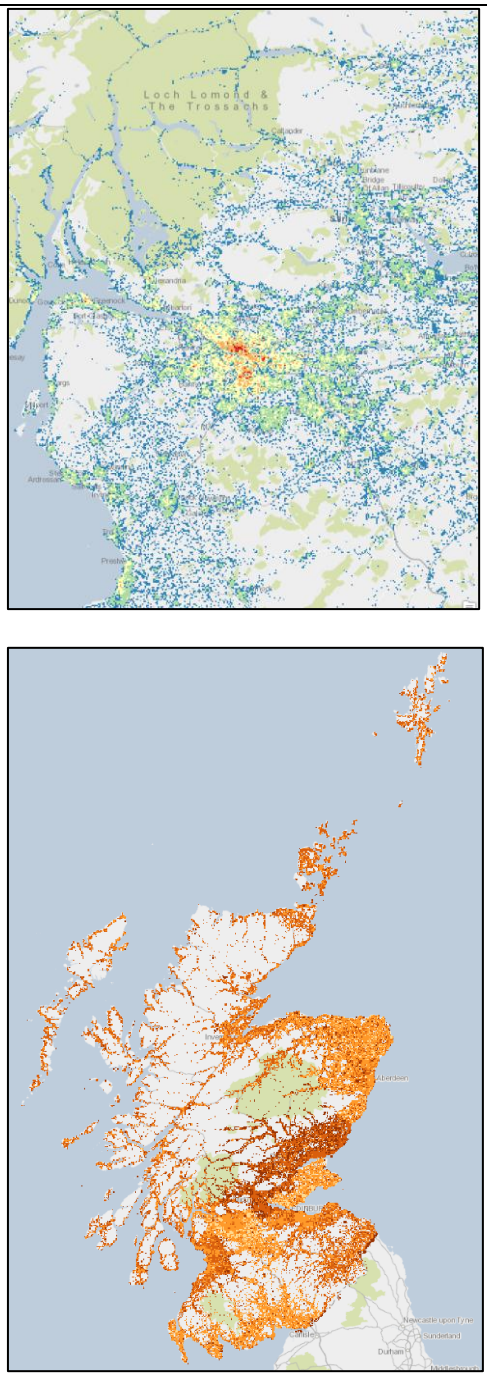
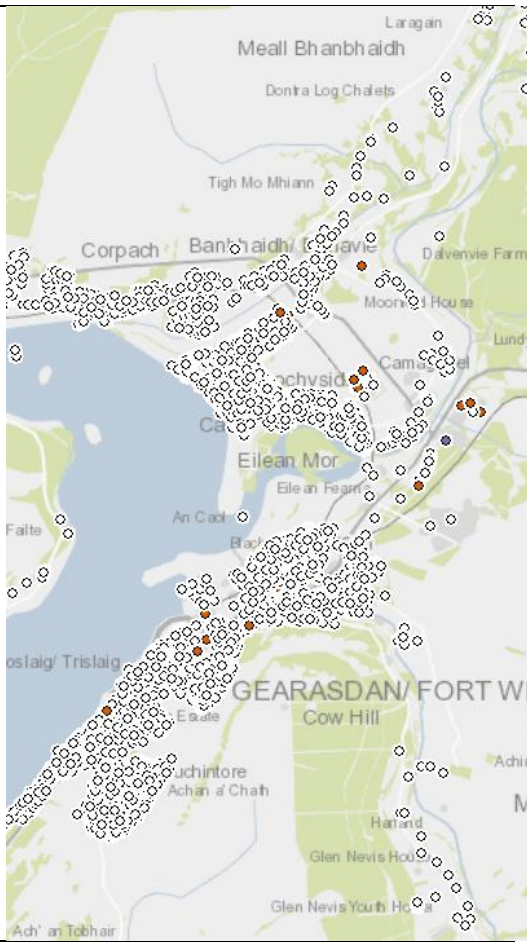
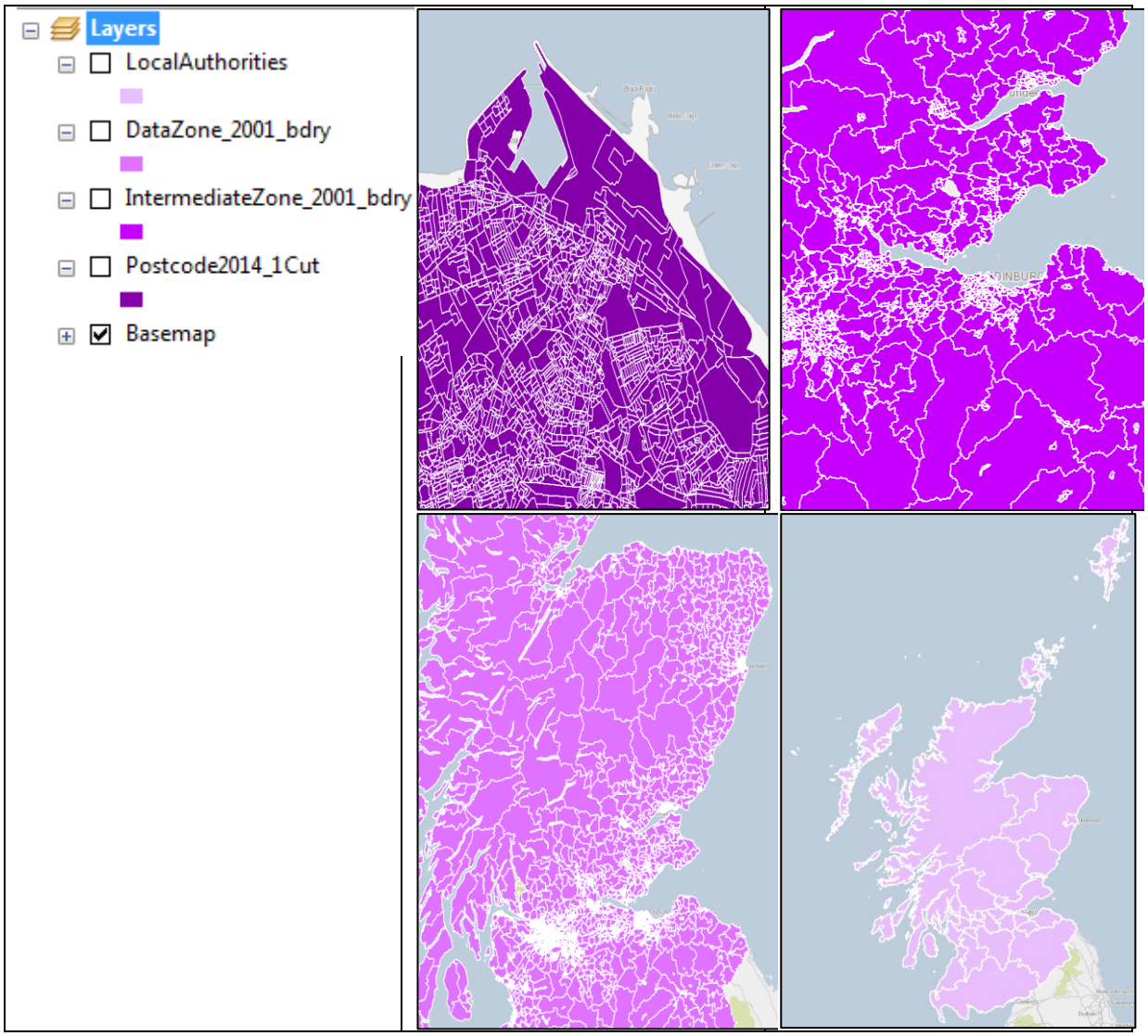
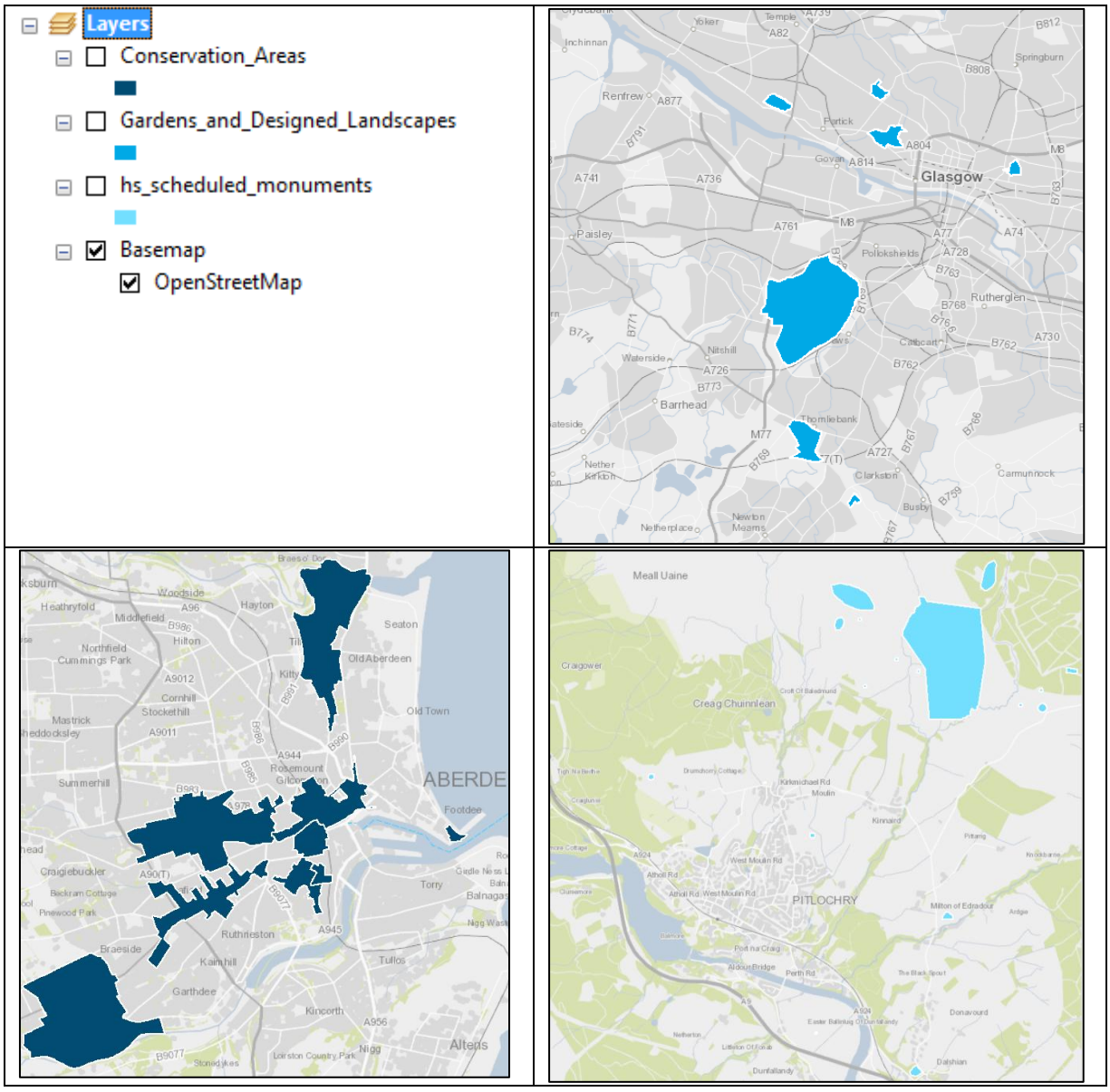


Table Of Contents Layers TotalHeatDemand <all other values> SourceType Business Other Public AssrDomestic AssrNonDomestic EPCHeatDemand ePimsHeatDemandDistinct ProcurementNaturalGasDemandDistinct SFHACarbonMatched SWAHeatDemand Basemap	RGB Orange (217,95,2) Purple (117,112,179) (190,232,255) (190,210,255) (115,178,255) (0,112,255) (0,92,230) (0,77,168) (0,38,115)	

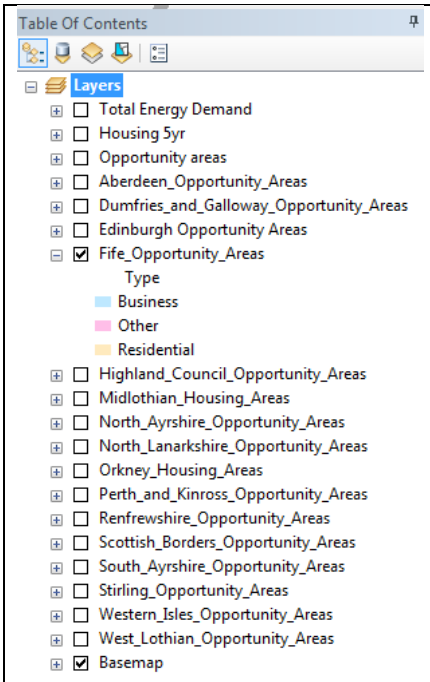
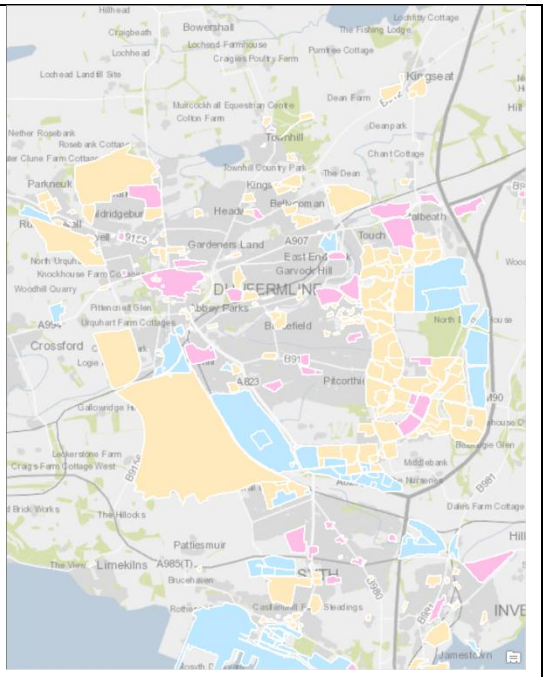
Layer Options (refer to p.29)



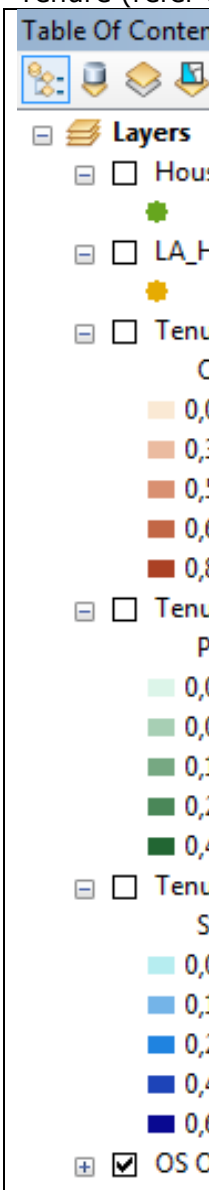
Opportunities and constraints (refer to p.28)



Planning and Economic development (refer to p.24)

	RGB Blue (190,232,255) Pink (255,190,232) Yellow (255,234,190)	

Tenure (refer to p.24)



RGB

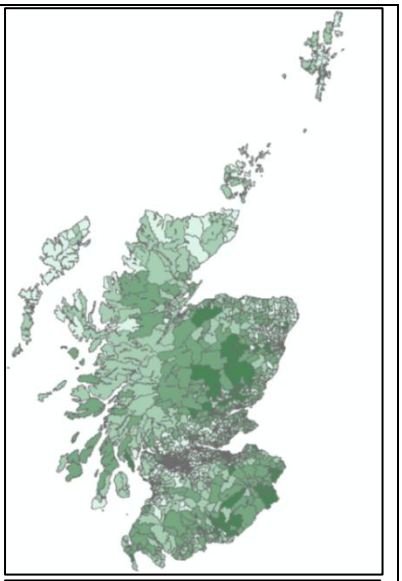
(102,166,30)

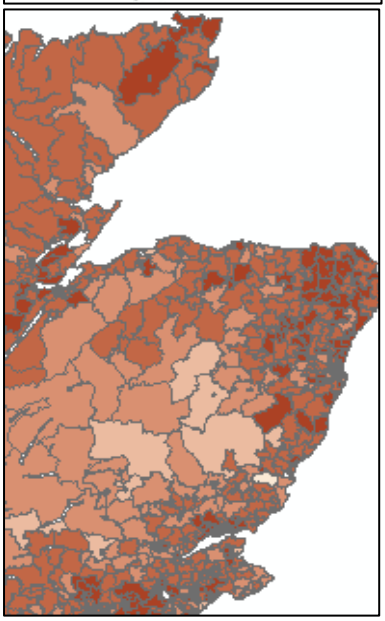
(230,171,2)

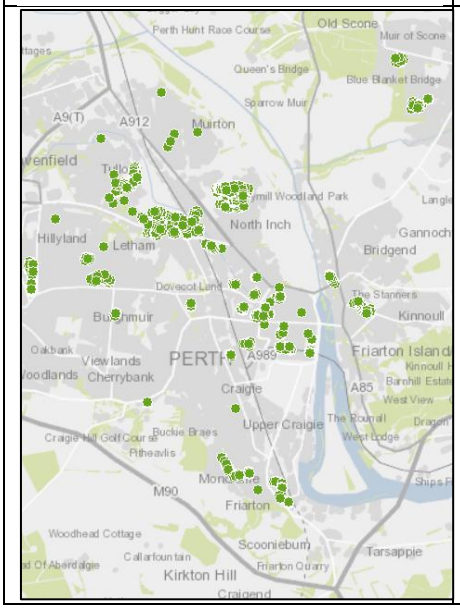
(250,233,212)
(235,187,160)
(217,144,113)
(194,103,70)
(171,65,36)

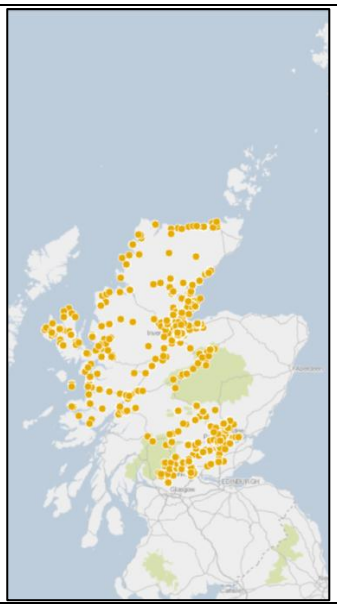
(220,245,233)
(167,207,180)
(118,168,130)
(74,135,88)
(34,102,51)

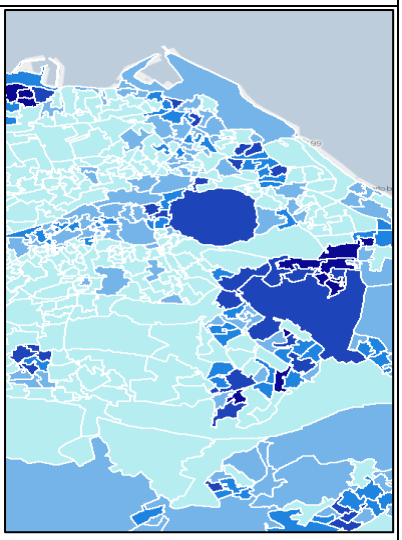
(182,237,240)
(116,180,232)
(31,131,224)
(29,68,184)
(9,9,145)











Utilities Layout (refer to p.29)